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(54) **TILTING LANDING GEAR SYSTEMS AND METHODS**

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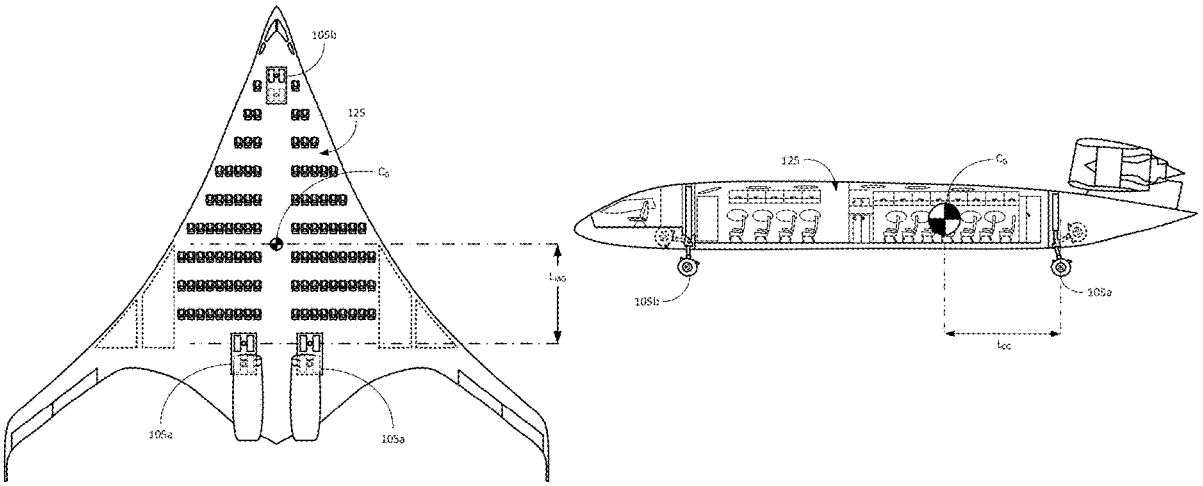
(57) **ABSTRACT**

Systems and methods for mechanically rotating an aircraft about its center-of-gravity (C_G) are disclosed. The system can enable the rear, or main, landing gear to squat, while the nose landing gear raises to generate a positive angle of attack for the aircraft for takeoff or landing. The system can also enable the nose gear and main gear to return to a relatively level fuselage attitude for ground operations. The system can include one or more hydraulically linked hydraulic cylinders to control the overall height of the nose gear and the main gear. Because the hydraulic cylinders are linked, a change on the length of the nose cylinder generates a proportional, and opposite, change in the length of the main cylinder, and vice-versa. A method and control system for monitoring and controlling the relative positions of the nose gear and main gear is also disclosed.



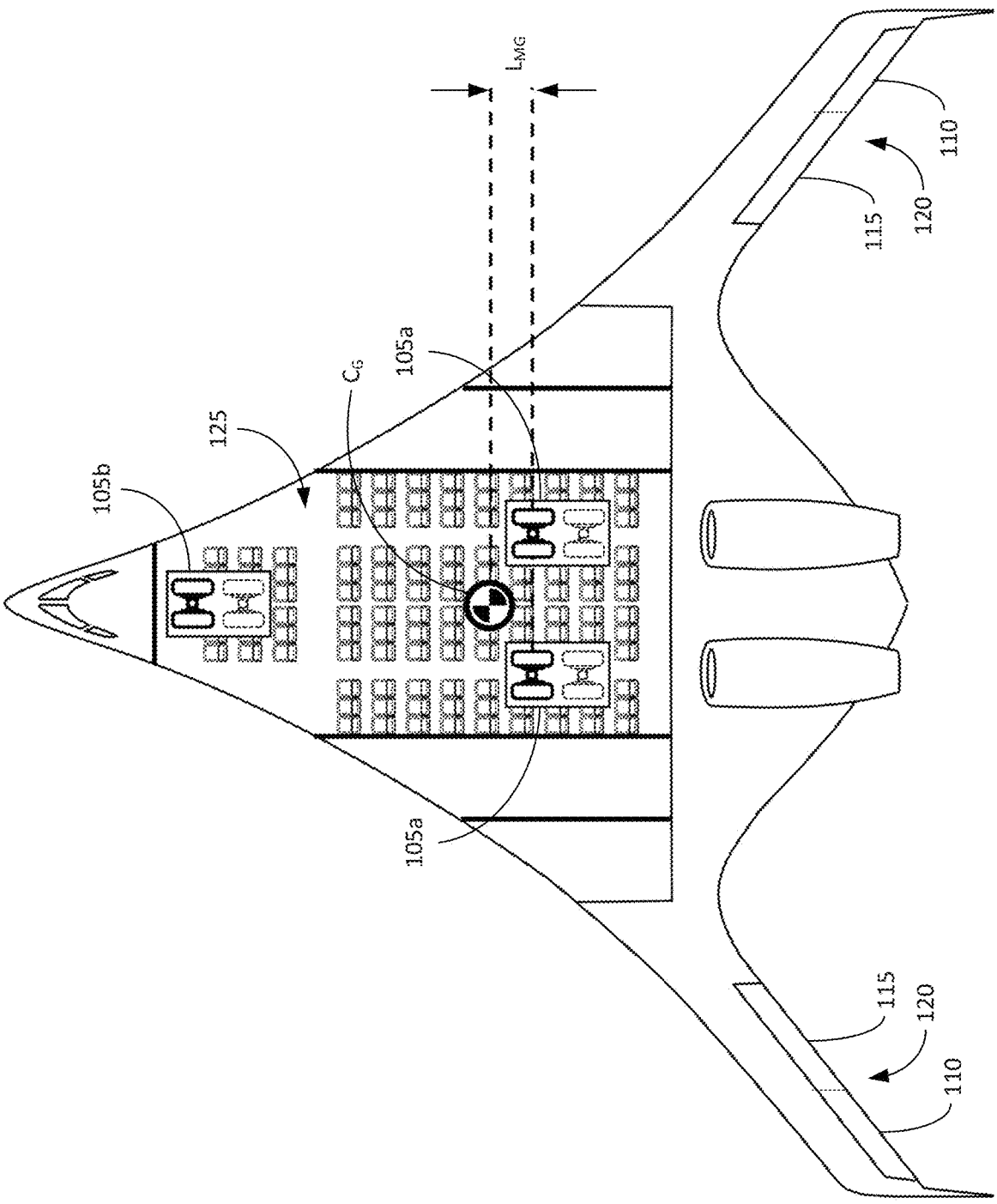


Fig. 1A
Prior Art

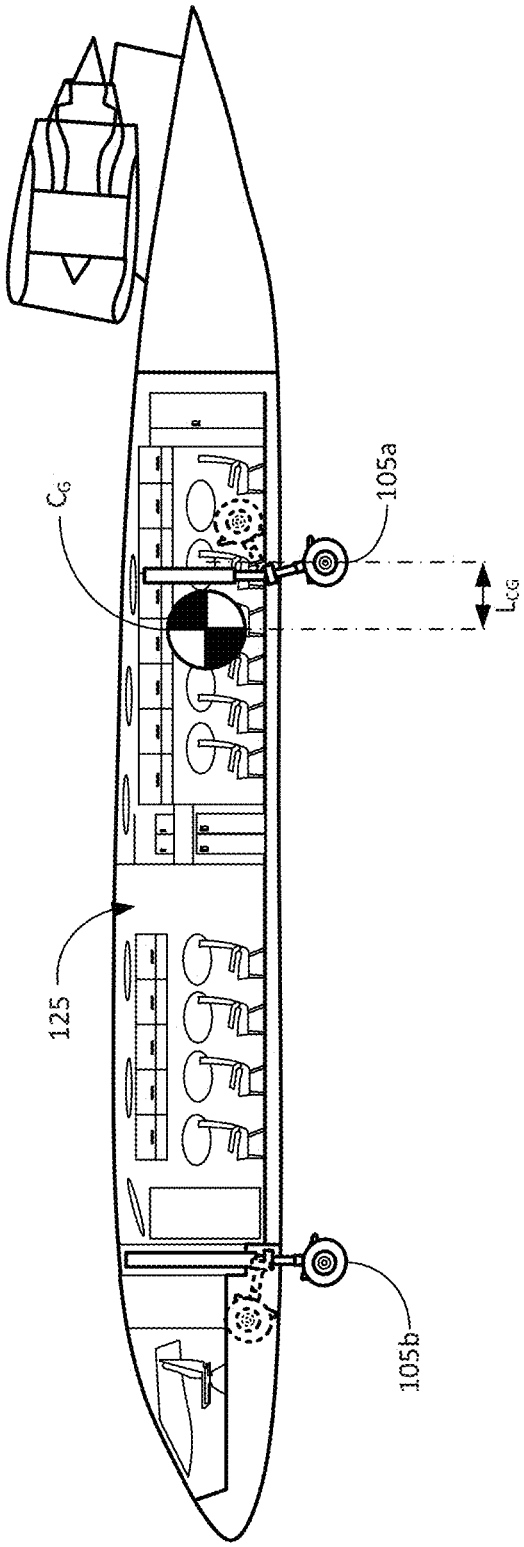


Fig. 1B
Prior Art

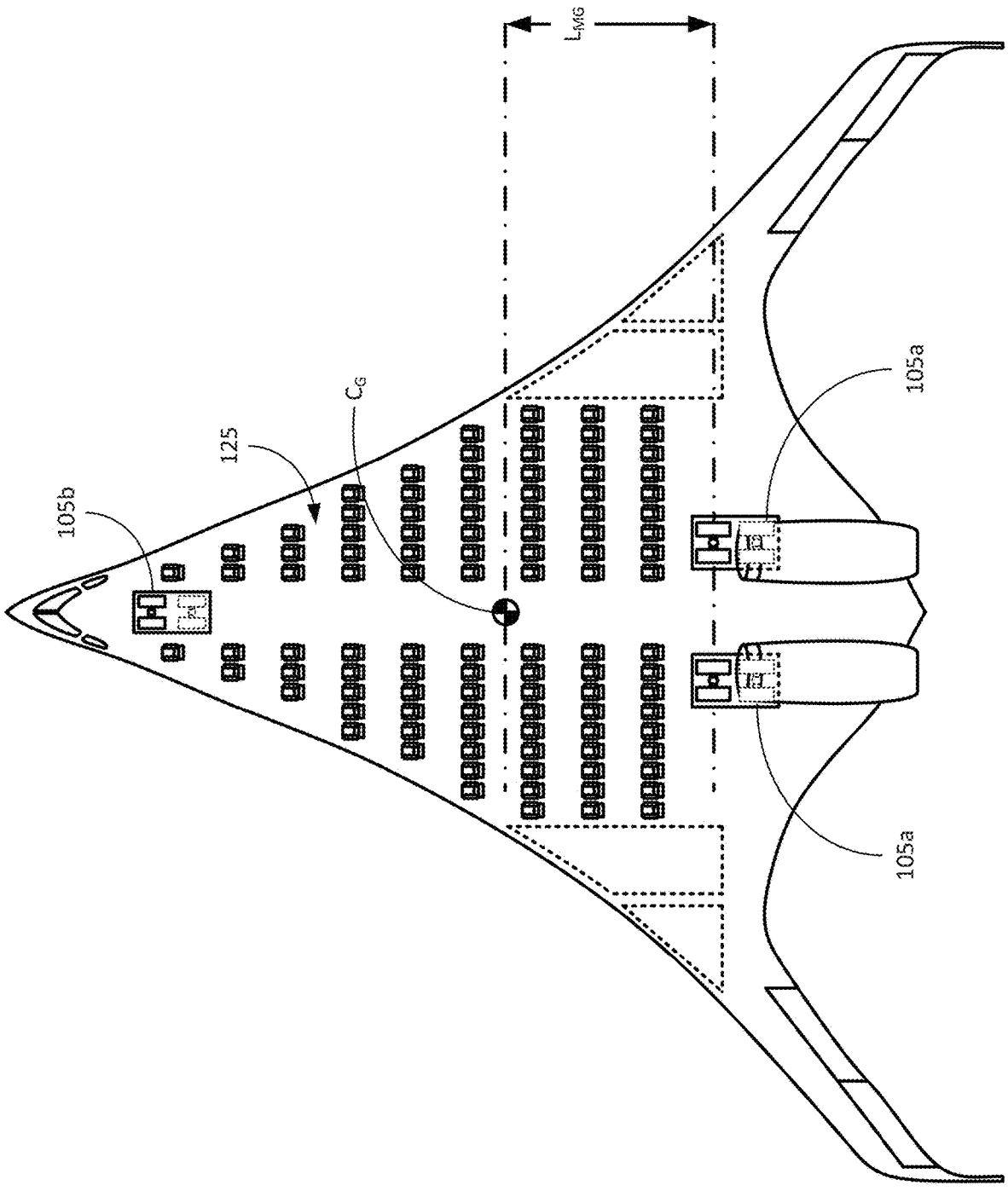


Fig. 2A

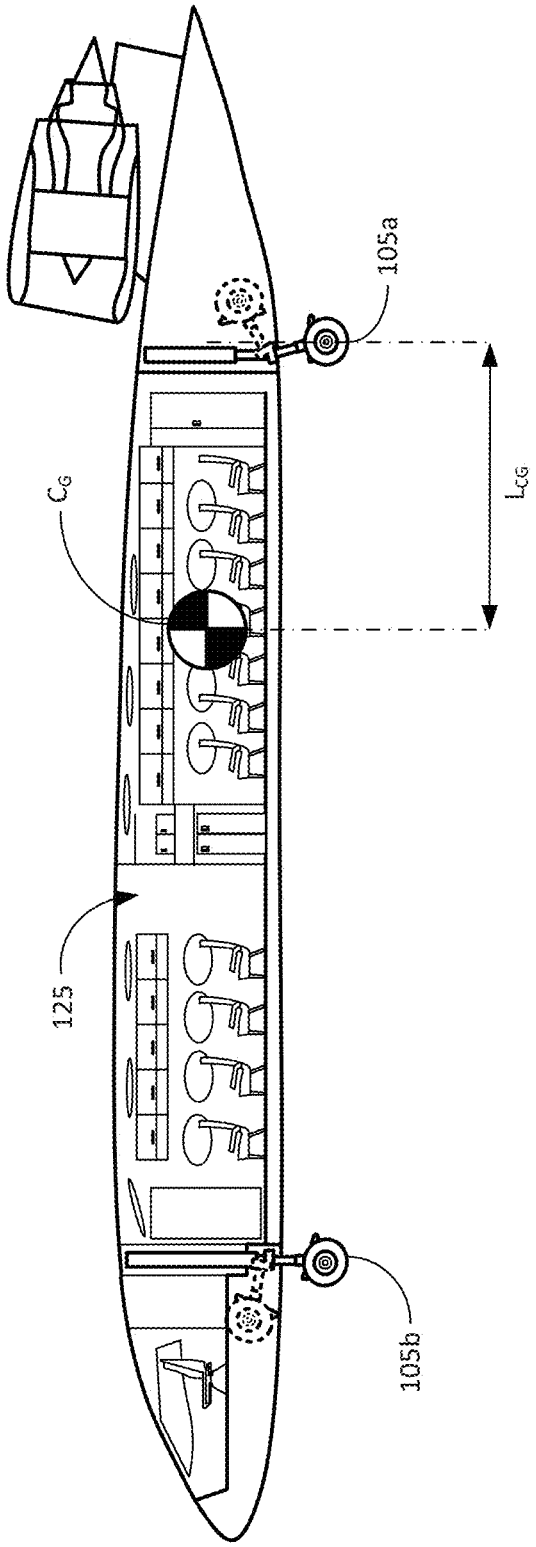


Fig. 2B

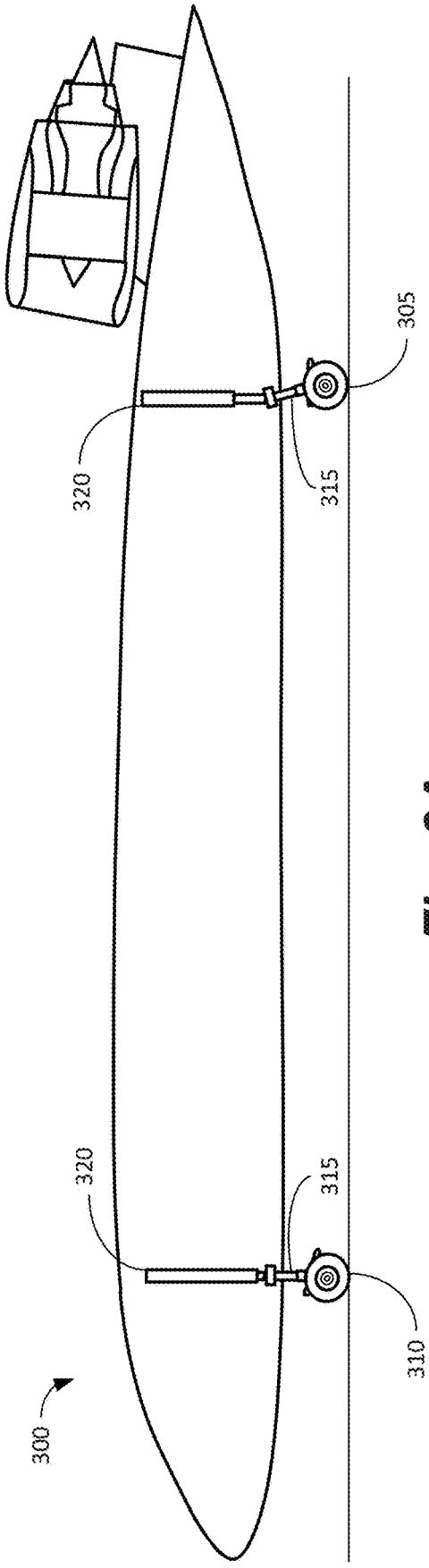

300
320
315
305
320
315
310

Fig. 3A

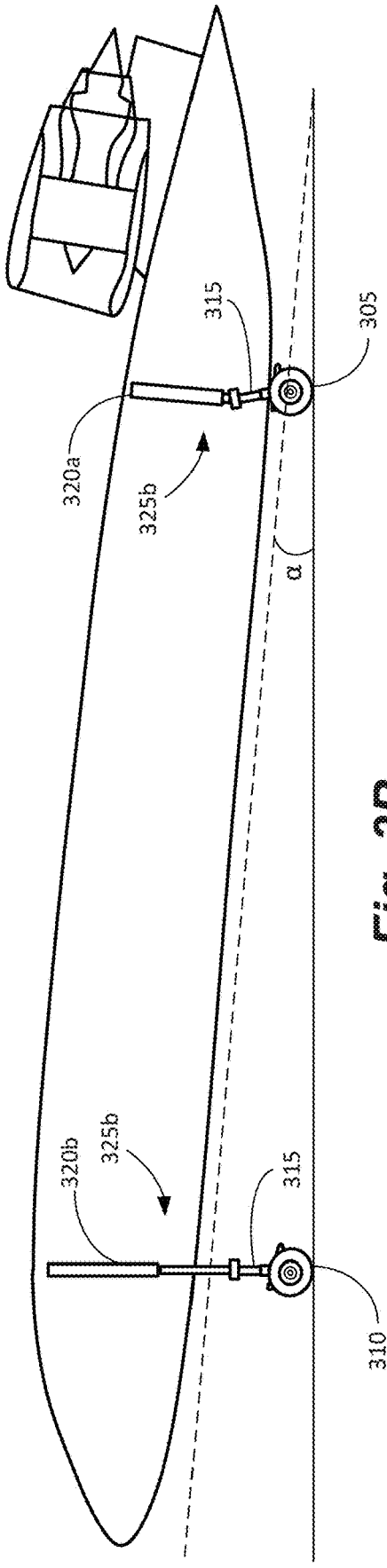

320a
325b
315
305
α
320b
325b
315
310

Fig. 3B

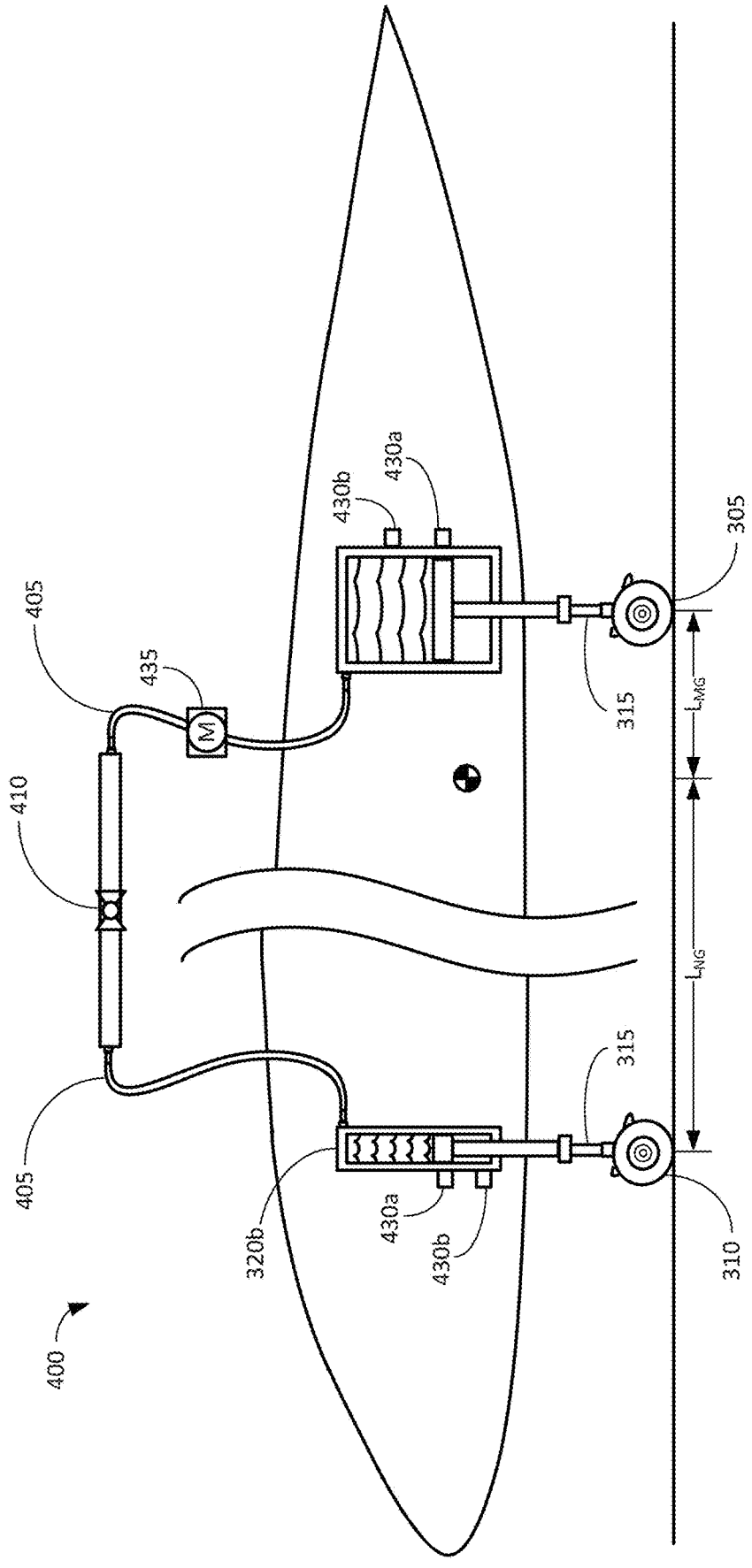

400
405
435
M
410
405
320b
430a
430b
430b
430a
315
315
305
310
L_{MG}
L_{NG}

Fig. 4A

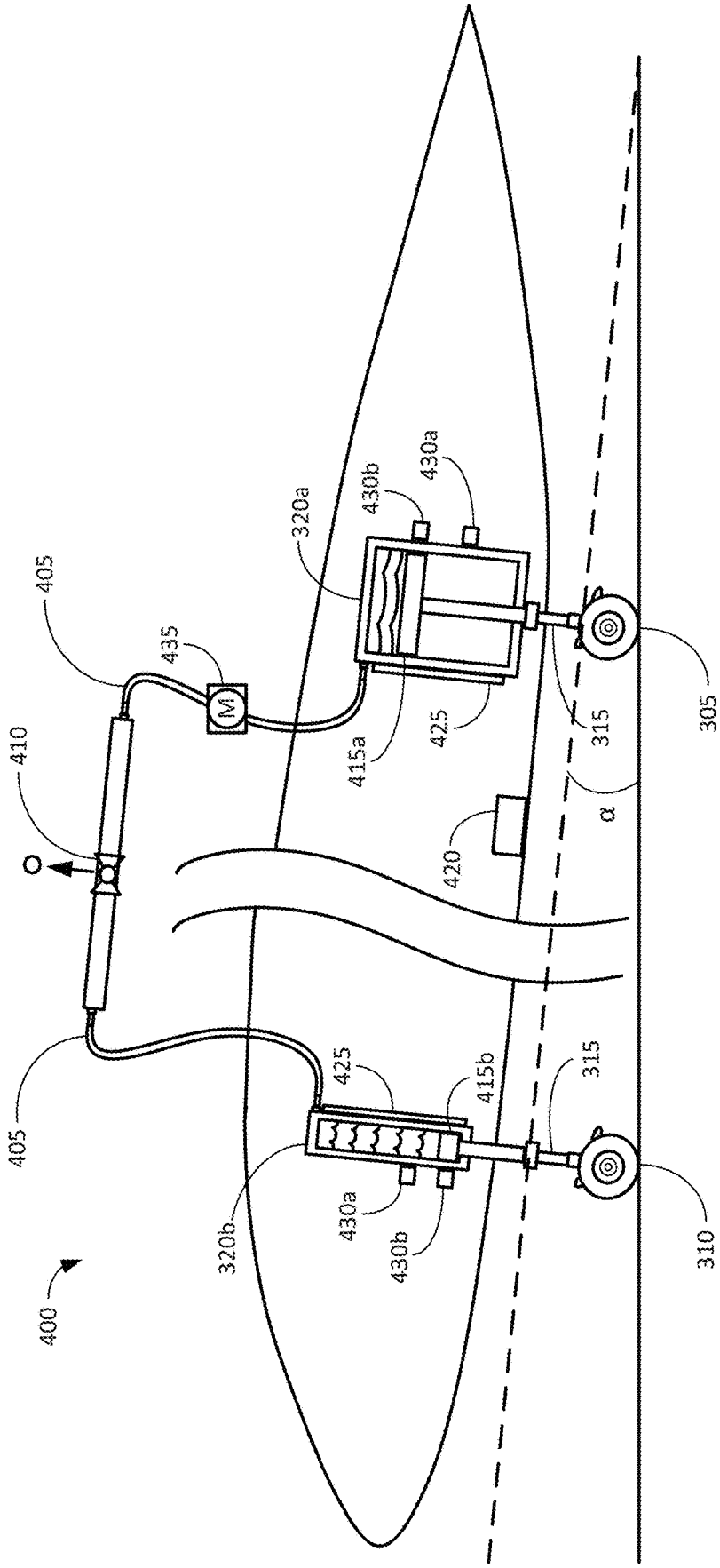

400
405
410
435
M
320a
430b
430a
415a
425
315
305
α
420
405
425
415b
315
320b
430a
430b
310

Fig. 4B

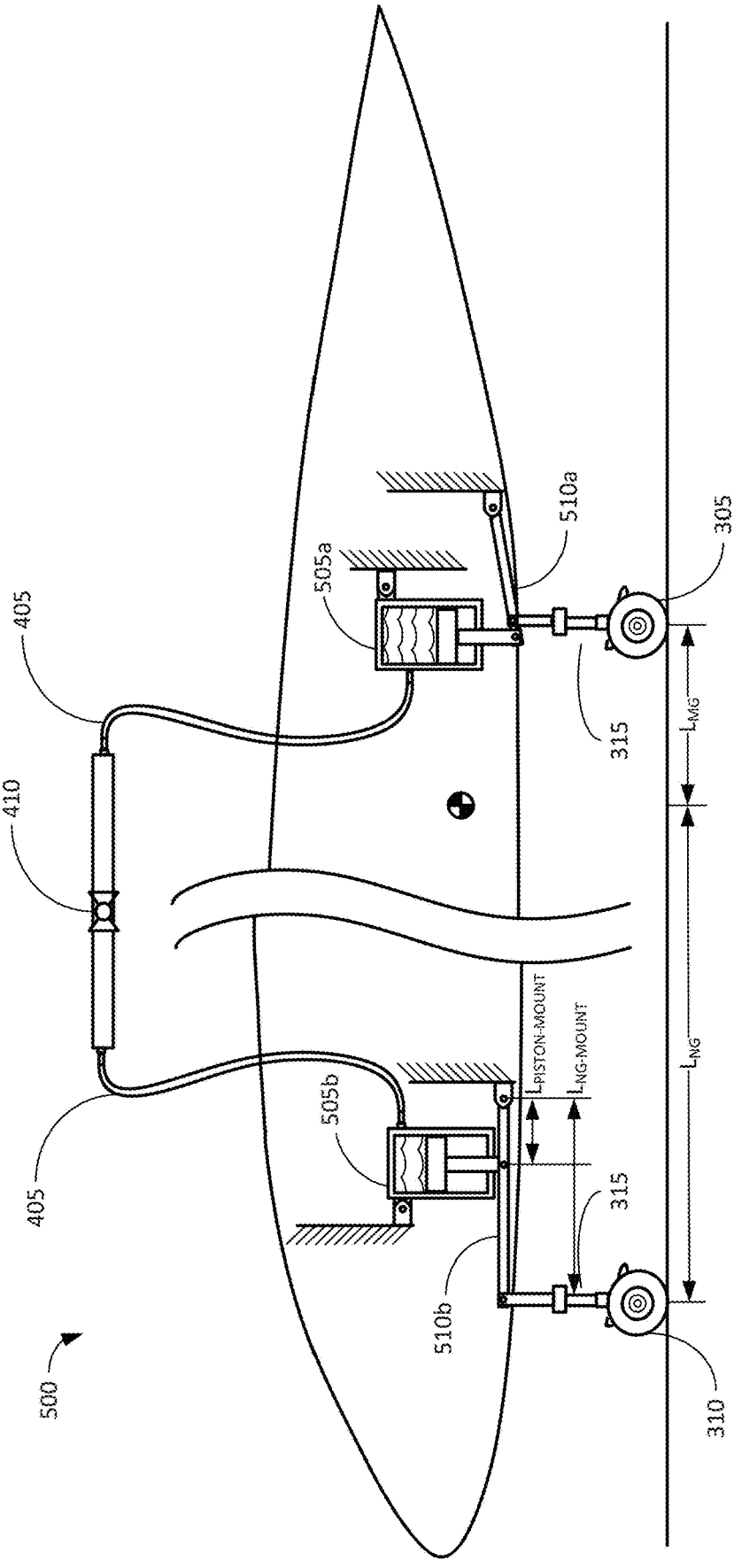

500
405
410
405
505a
505b
510a
510b
315
315
305
310
L_{MG}
L_{NG}
$L_{PISTON-MOUNT}$
$L_{NG-MOUNT}$

Fig. 5A

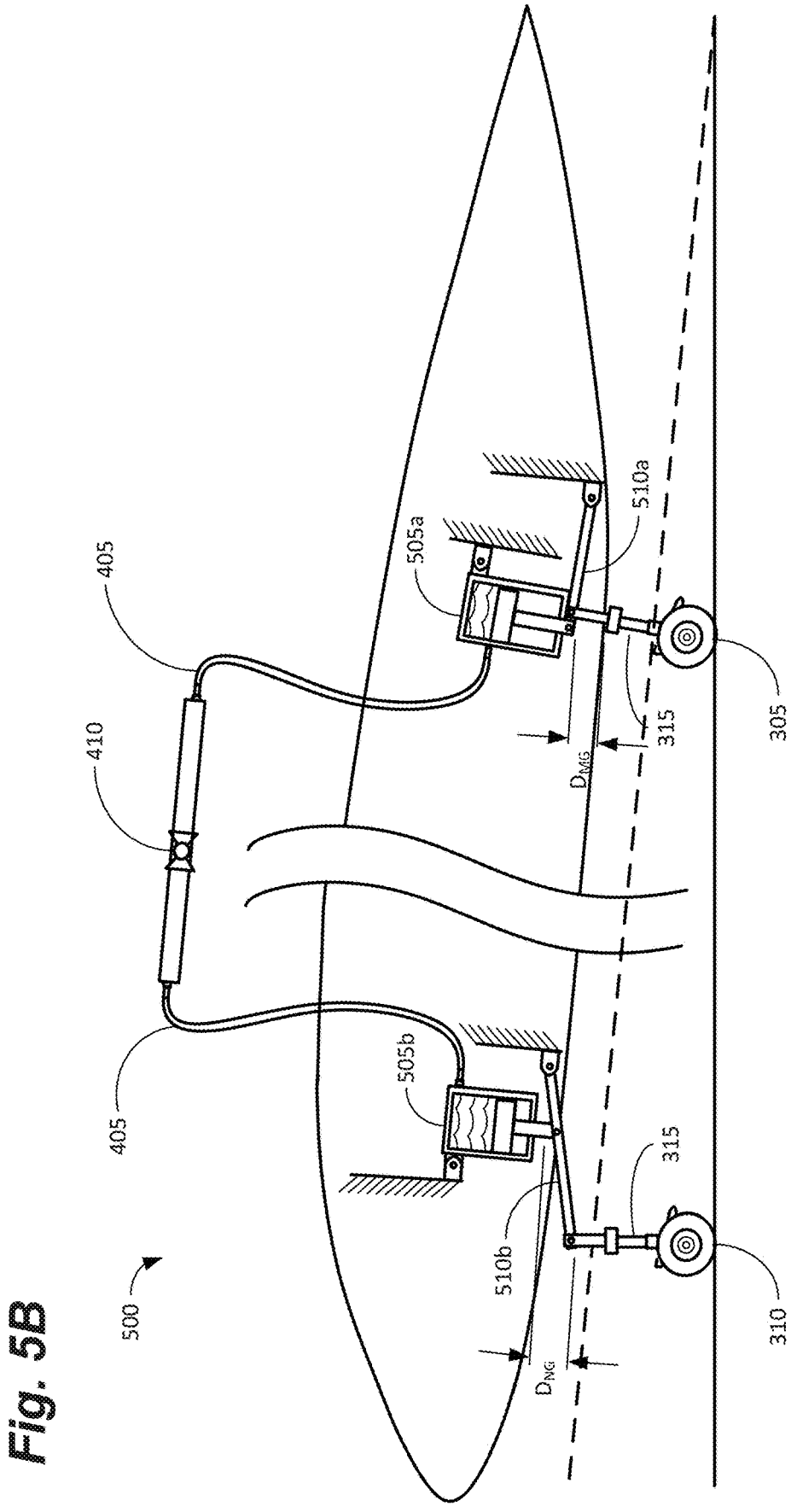


Fig. 5B

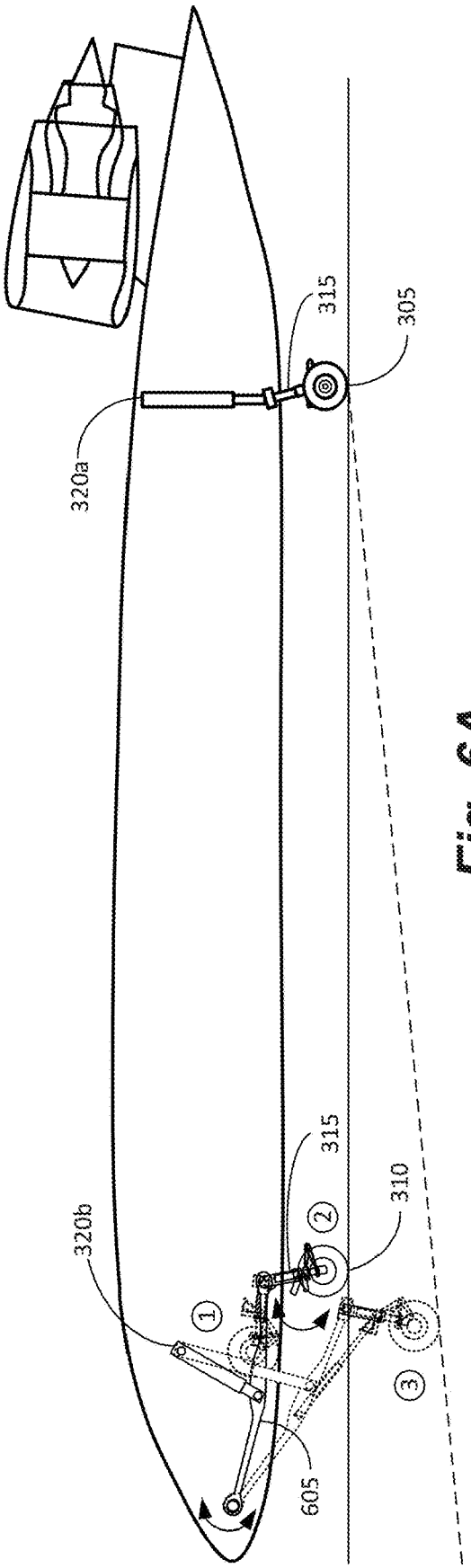

320a
315
305
320b
315
310
605
1
2
3

Fig. 6A

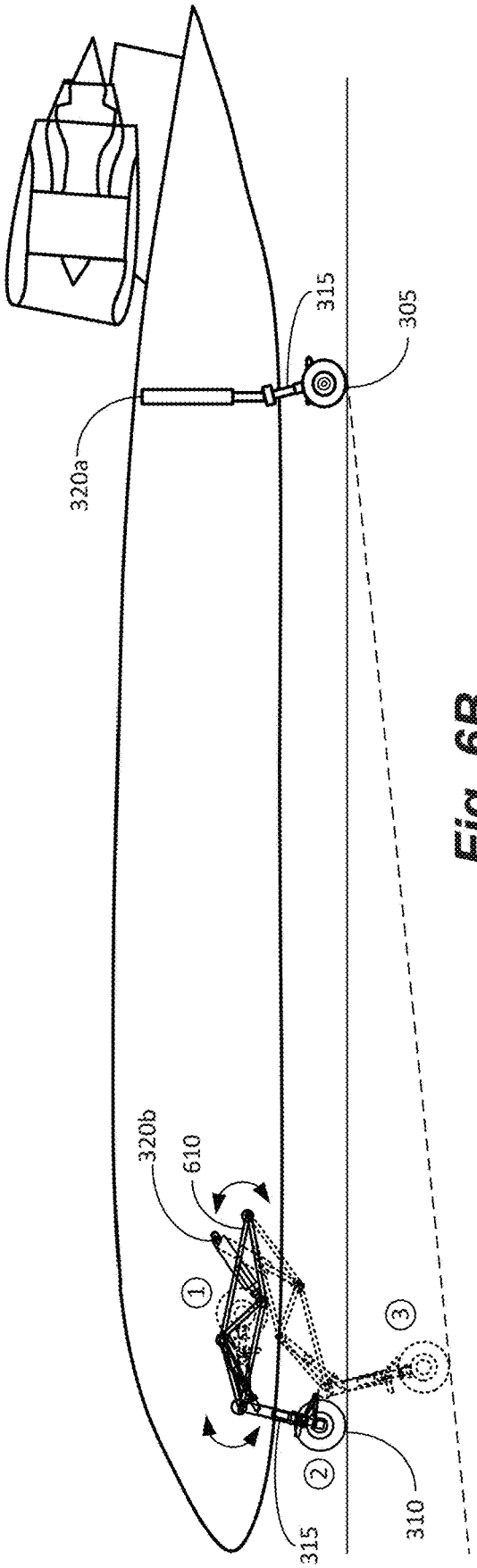

320a
315
305
320b
610
315
310
1
2
3

Fig. 6B

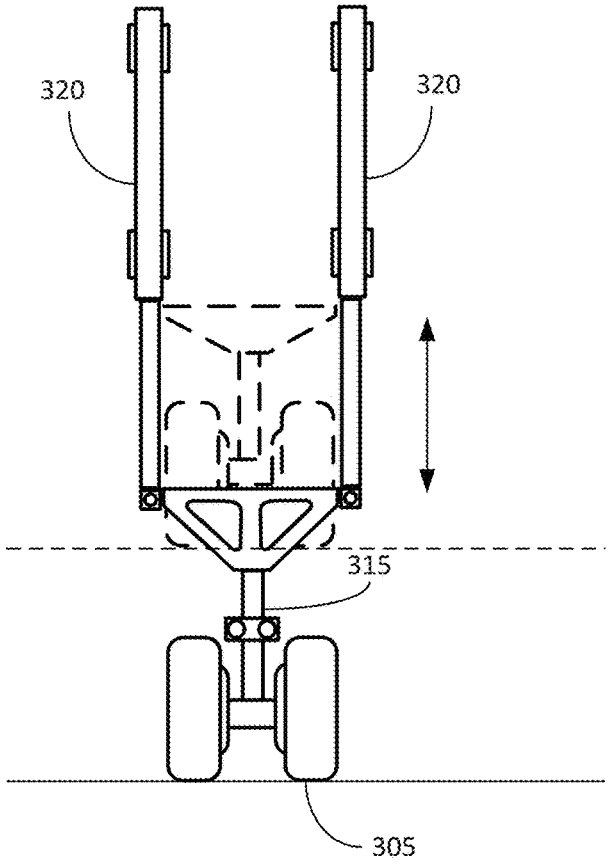


Fig. 7A

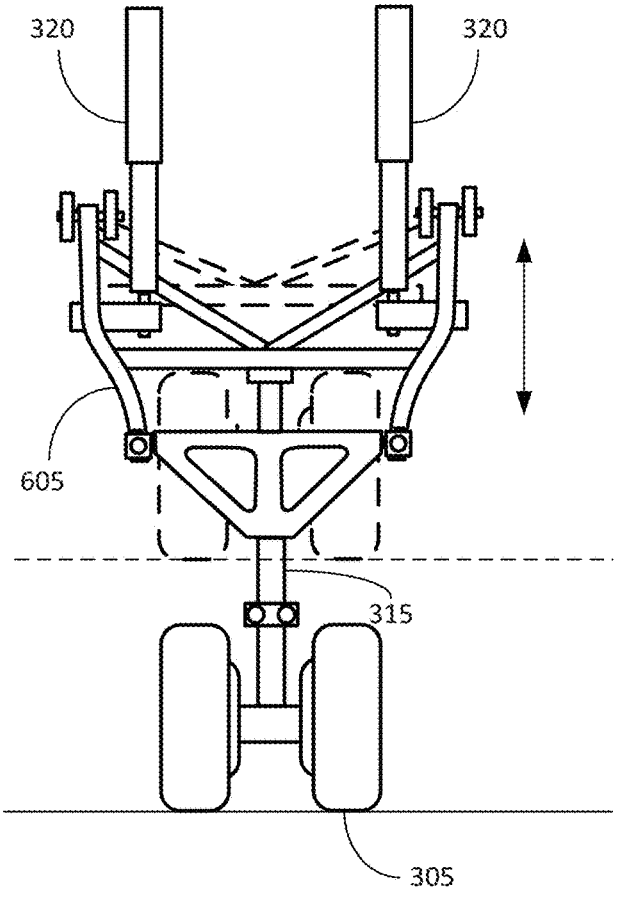


Fig. 7B

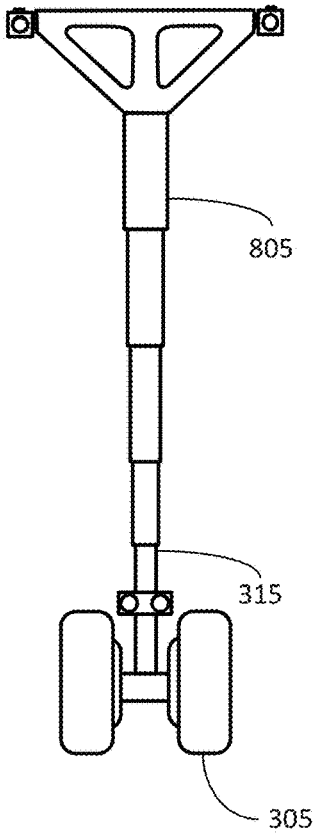


Fig. 8A

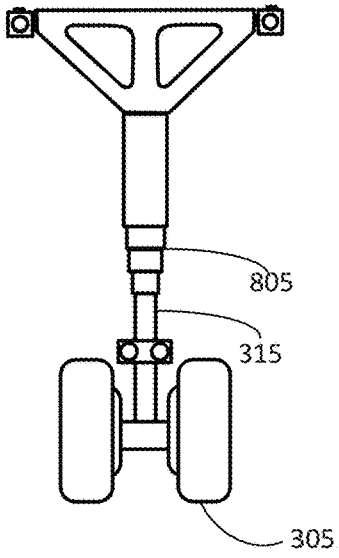


Fig. 8B

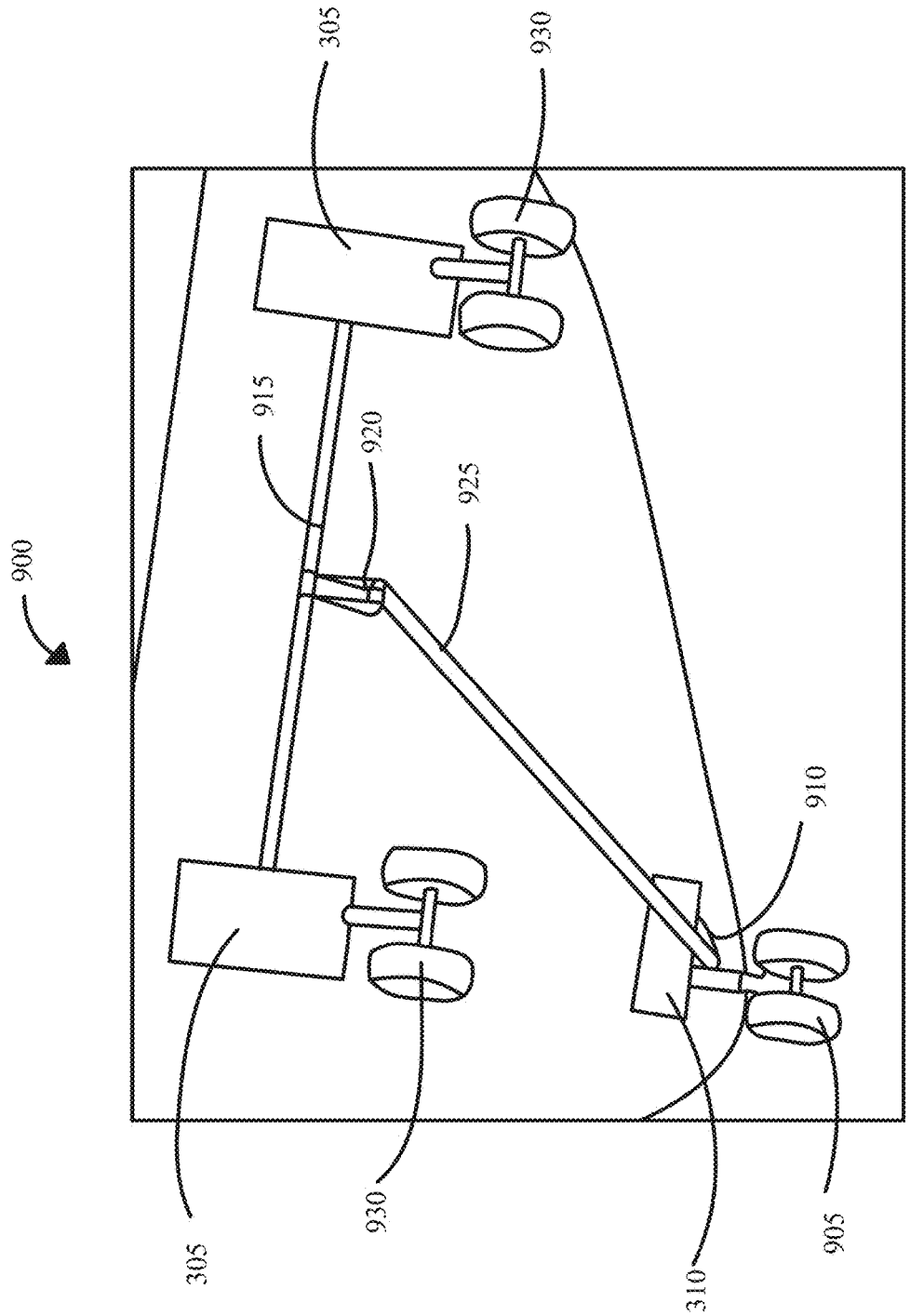


FIG. 9

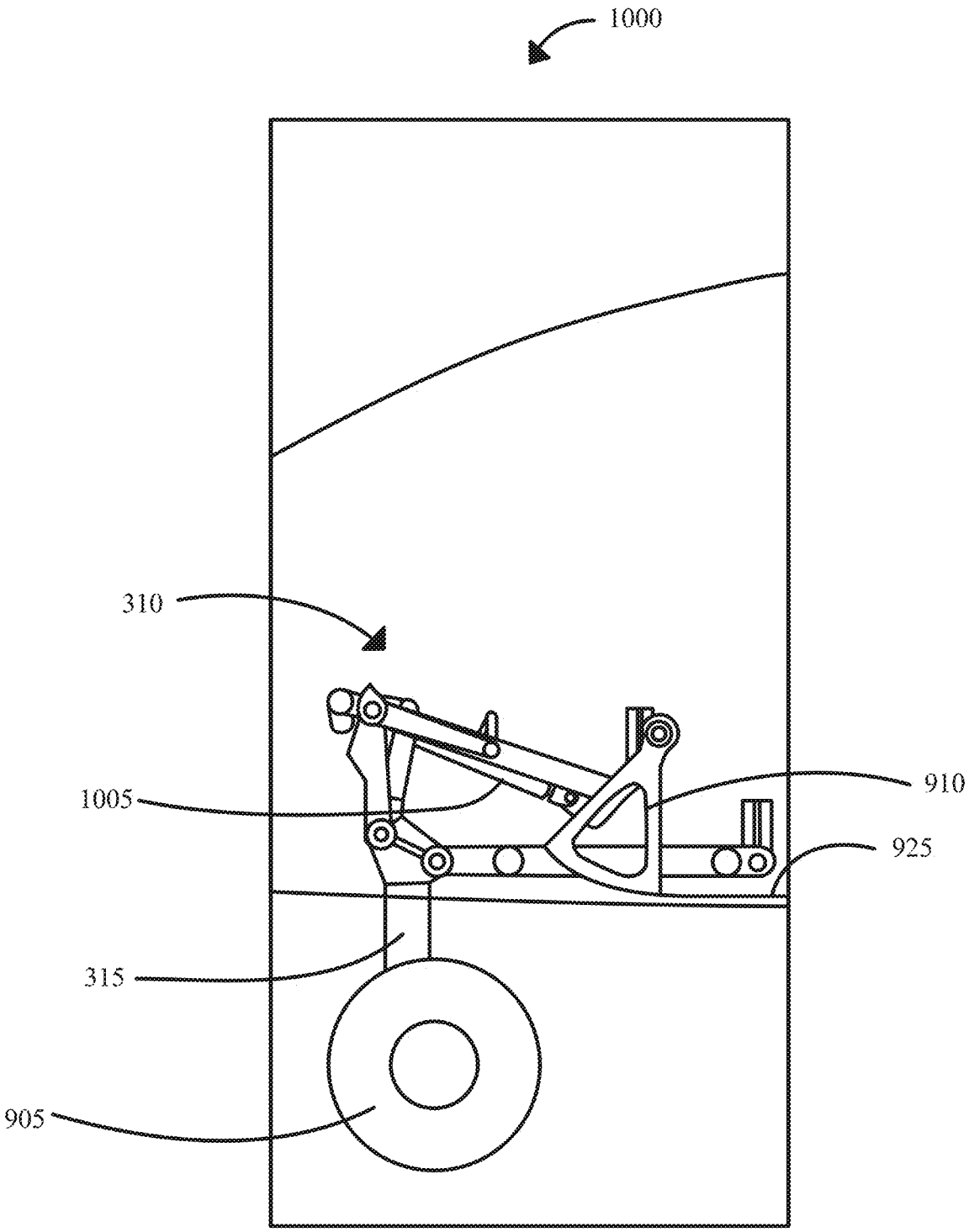


FIG. 10

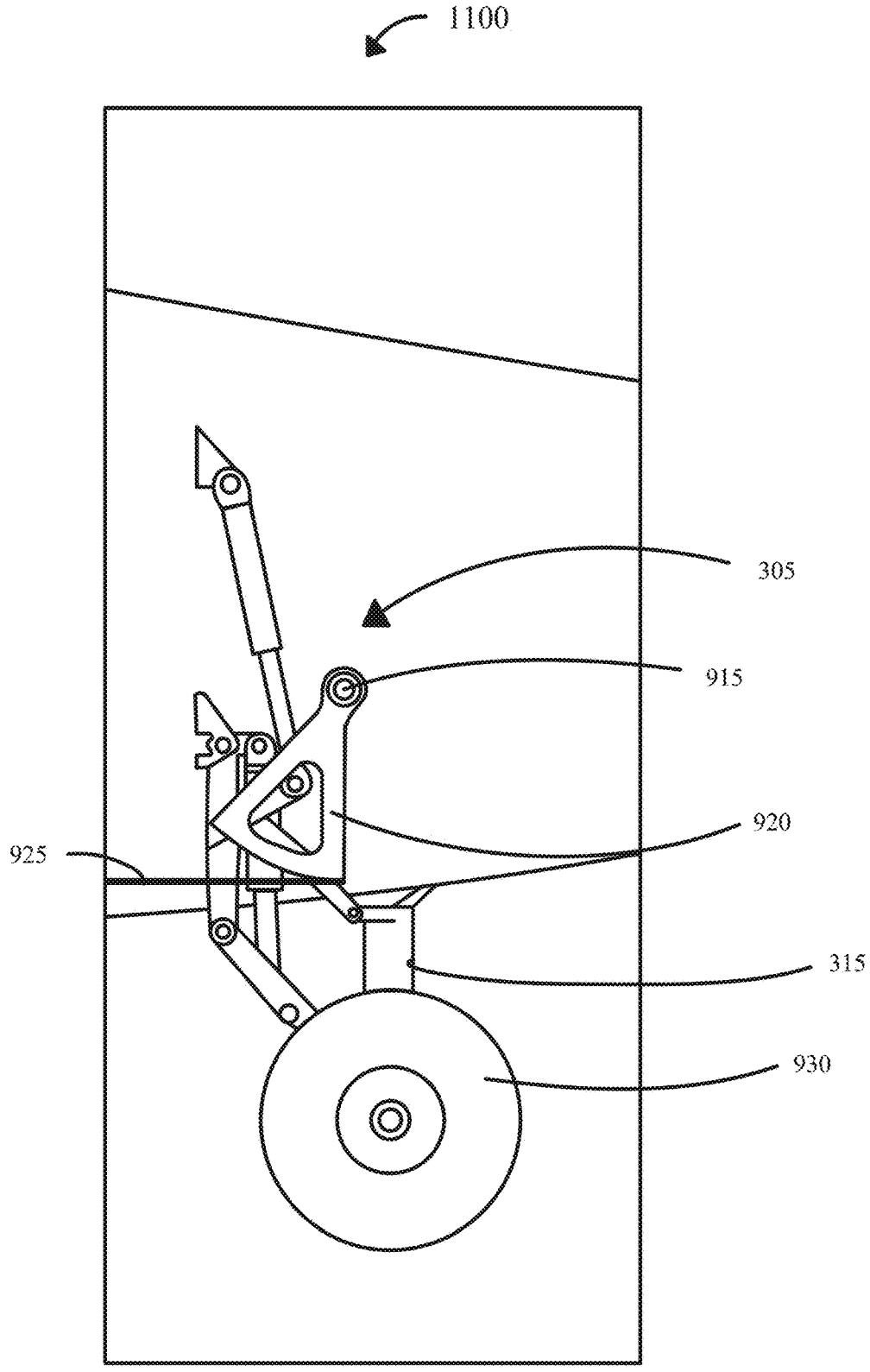


FIG. 11

Fig. 12

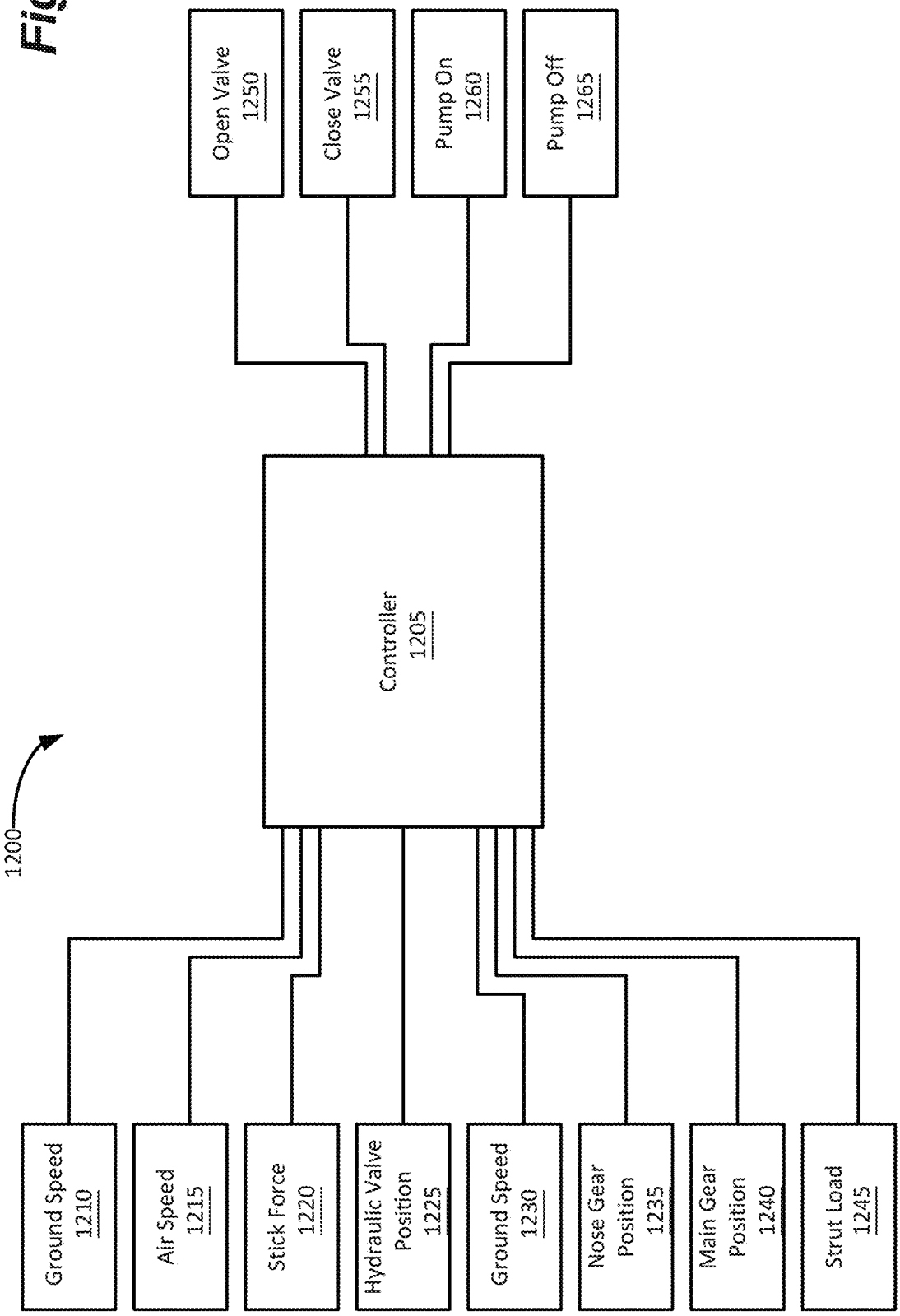

1200
Controller
1205
Open Valve
1250
Close Valve
1255
Pump On
1260
Pump Off
1265
Ground Speed
1210
Air Speed
1215
Stick Force
1220
Hydraulic Valve Position
1225
Ground Speed
1230
Nose Gear Position
1235
Main Gear Position
1240
Strut Load
1245

Fig. 13

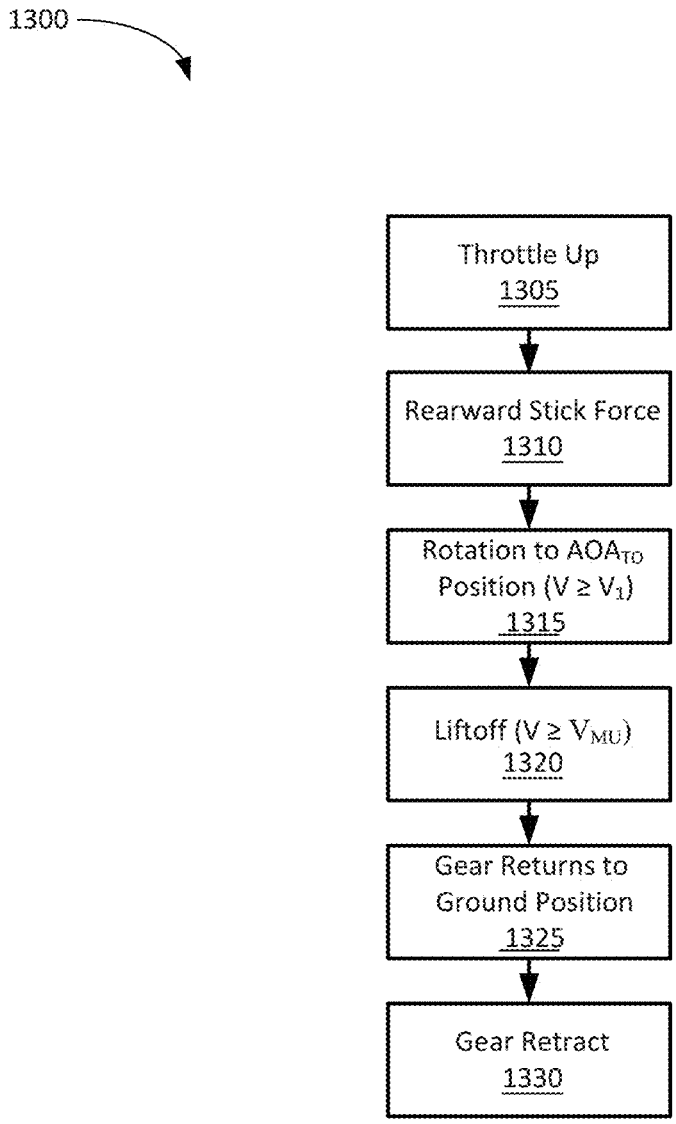

1300
Throttle Up
1305
Rearward Stick Force
1310
Rotation to AOA_{TO}
Position ($V \geq V_1$)
1315
Liftoff ($V \geq V_{MU}$)
1320
Gear Returns to
Ground Position
1325
Gear Retract
1330

Fig. 14

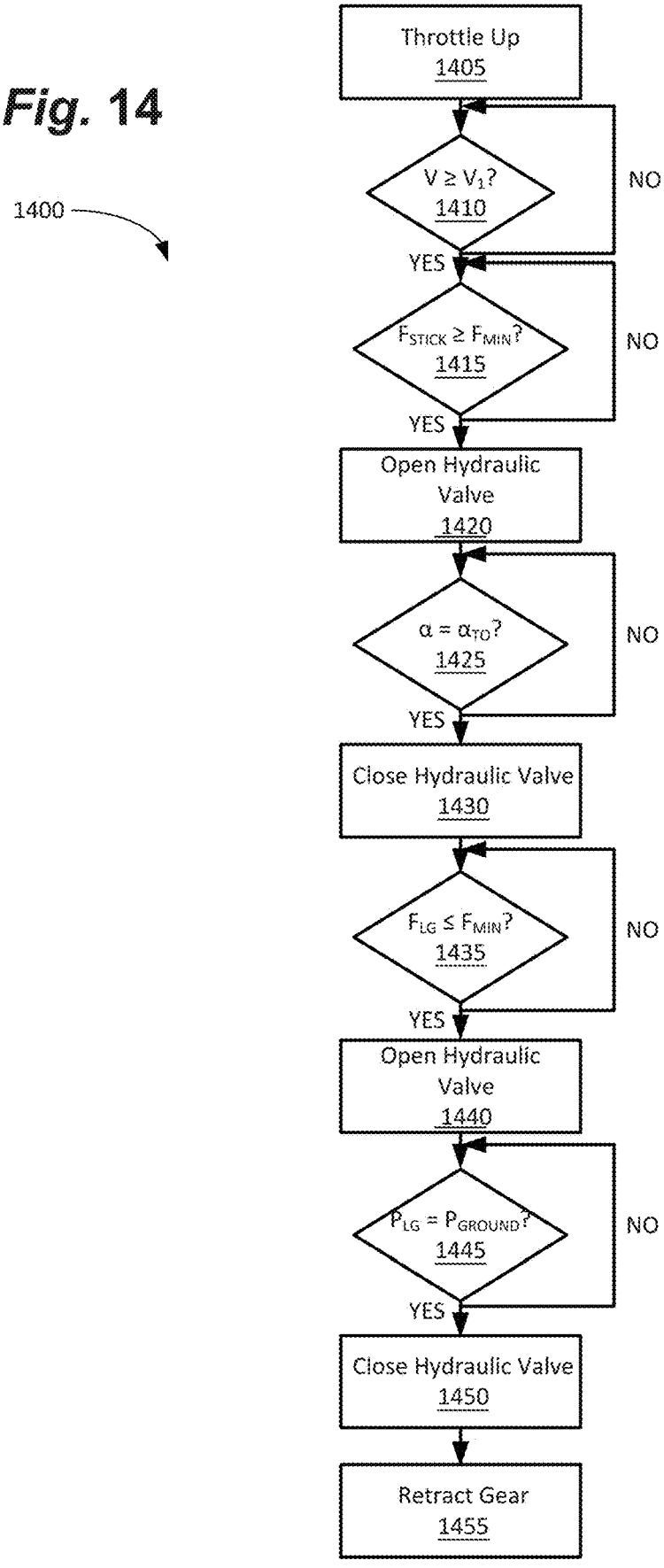
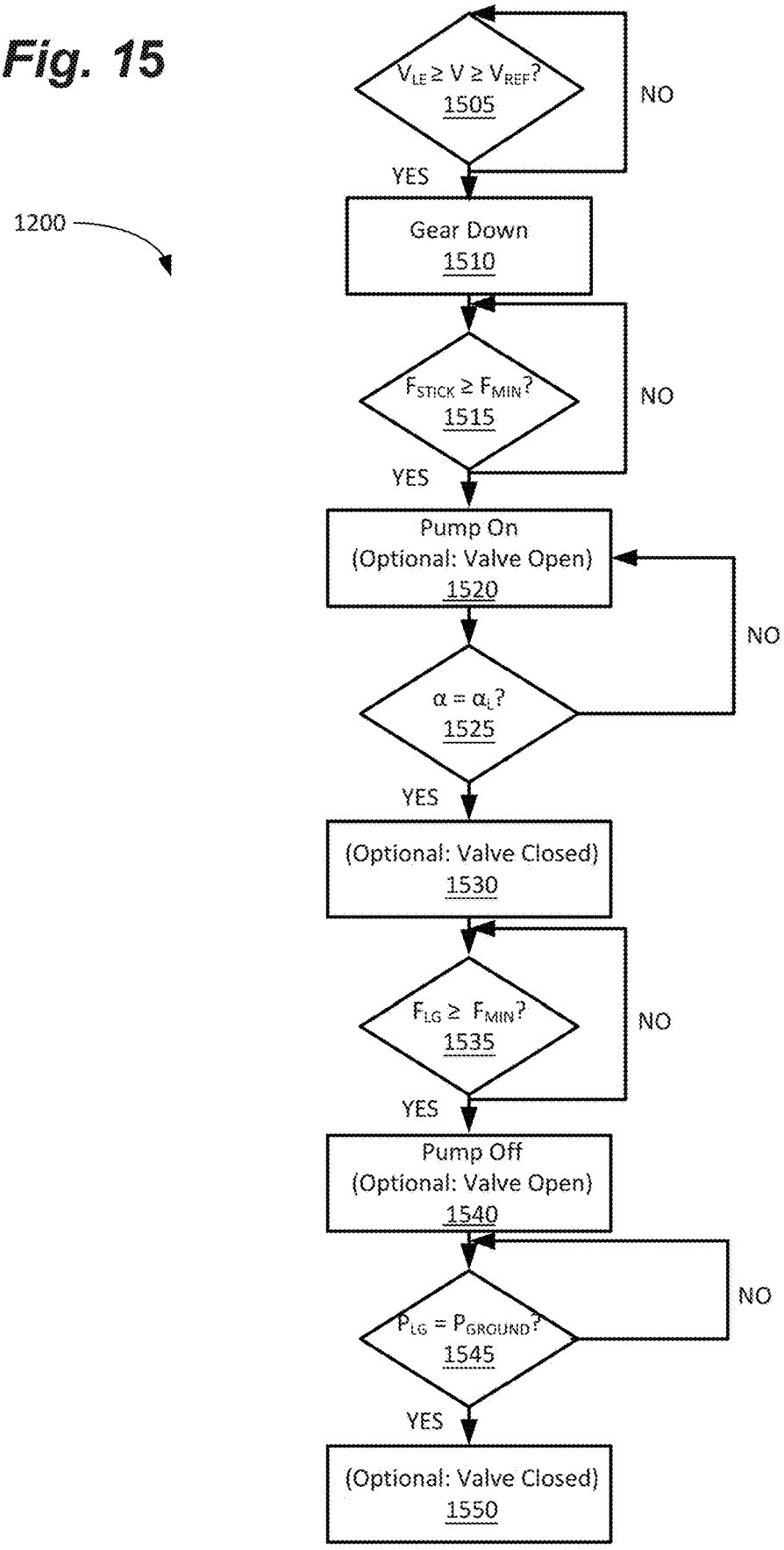

1400
Throttle Up
1405
V ≥ V1?
1410
NO
YES
FSTICK ≥ FMIN?
1415
NO
YES
Open Hydraulic Valve
1420
α = αTO?
1425
NO
YES
Close Hydraulic Valve
1430
FLG ≤ FMIN?
1435
NO
YES
Open Hydraulic Valve
1440
PLG = PGROUND?
1445
NO
YES
Close Hydraulic Valve
1450
Retract Gear
1455

Fig. 15


1200
$V_{LE} \geq V \geq V_{REF}$?
1505
NO
YES
Gear Down
1510
$F_{STICK} \geq F_{MIN}$?
1515
NO
YES
Pump On
(Optional: Valve Open)
1520
NO
$\alpha = \alpha_L$?
1525
YES
(Optional: Valve Closed)
1530
$F_{LG} \geq F_{MIN}$?
1535
NO
YES
Pump Off
(Optional: Valve Open)
1540
NO
$P_{LG} = P_{GROUND}$?
1545
YES
(Optional: Valve Closed)
1550

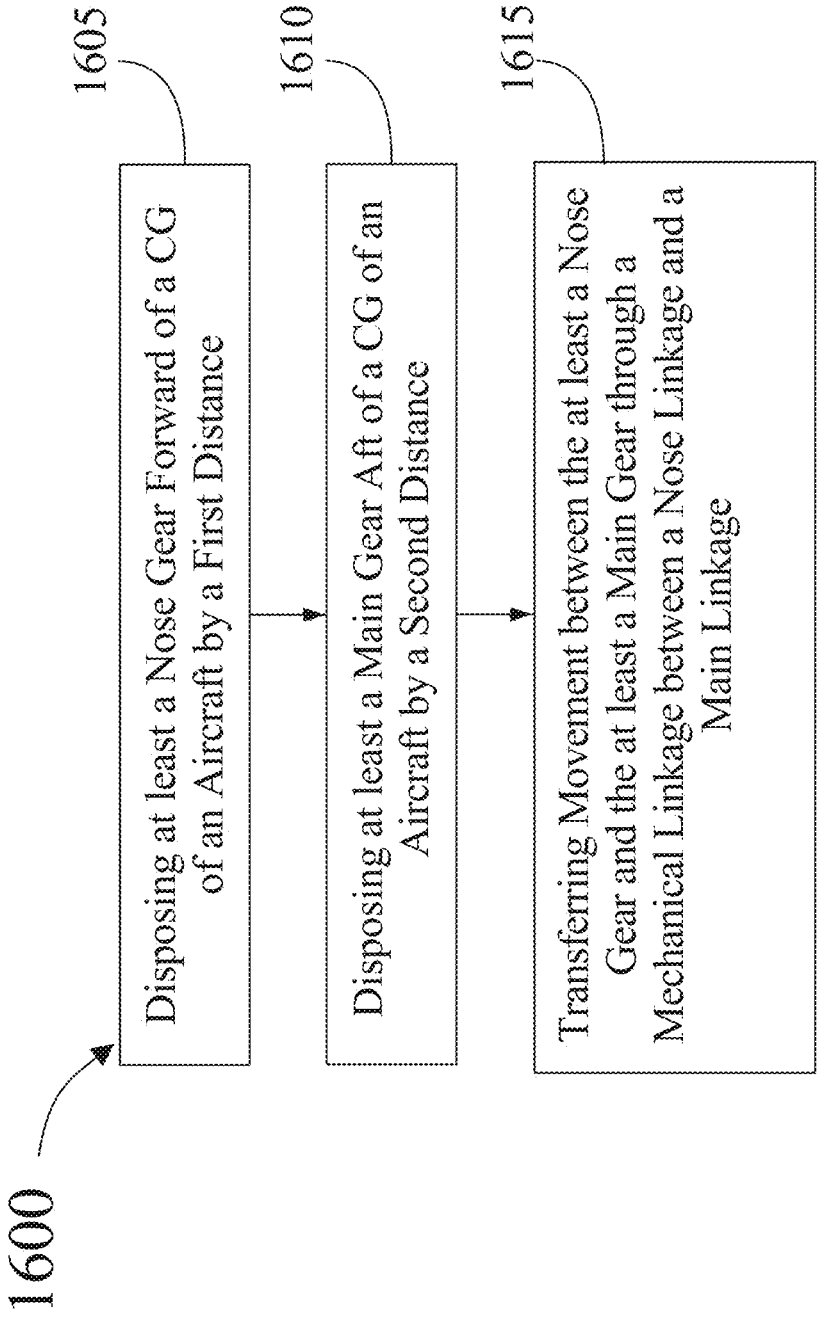

1600
1605
Disposing at least a Nose Gear Forward of a CG of an Aircraft by a First Distance
1610
Disposing at least a Main Gear Aft of a CG of an Aircraft by a Second Distance
1615
Transferring Movement between the at least a Nose Gear and the at least a Main Gear through a Mechanical Linkage between a Nose Linkage and a Main Linkage

FIG. 16

TILTING LANDING GEAR SYSTEMS AND METHODS

CROSS-REFERENCE TO RELATED APPLICATIONS

[0001] The present disclosure is a continuation-in-part of U.S. patent application Ser. No. 17/512,421, filed Oct. 27, 2021, of the same title, which in turn is a continuation of and claims priority under 35 U.S.C. § 120 to U.S. patent application Ser. No. 16/181,687, filed Nov. 6, 2018, of the same title, which in turn is a continuation of, and claims priority to U.S. patent application Ser. No. 15/198,611, filed Jun. 30, 2016, of the same title, all of which are hereby incorporated by reference as if fully set forth below.

FIELD OF THE INVENTION

[0002] The present invention generally relates to the field of aircraft. In particular, the present invention is directed to tilting landing gear systems and methods.

BACKGROUND

[0003] Presently, air travel accounts for a large proportion of greenhouse gas emissions. Furthermore, these emissions typically occur at increased elevations within the atmosphere, exacerbating their impact.

SUMMARY OF THE DISCLOSURE

[0004] Conventional aircraft consist essentially of a wing section and a fuselage. This so-called "tube and wing" configuration enables convenient packaging of passengers and cargo but has certain drawbacks. In most cases, passengers are seated on a deck disposed approximately on the vertical centerline of the fuselage, while cargo is stowed beneath. This enables a relatively wide, flat floor for seats and separates cargo operations from passenger loading and unloading. Passengers can be loaded via one or more passenger doors, while cargo can be loaded from one or more cargo hatches on the underside or sides of the fuselage. This configuration also provides a relative constant fuselage cross section (less the nose and tail cones), enabling a substantially percentage of the available volume of the fuselage to be utilized.

[0005] While convenient from a packaging standpoint, the tube and wing configuration is not particularly efficient. This is because the fuselage provides little or no lift yet introduces substantial drag. Thus, the wing must provide substantially all of the lift required for the aircraft to fly. This configuration requires a wing that is larger, thicker, and/or more cambered than would otherwise be required (i.e., if the fuselage provided a larger percentage of the required lift). This results in a wing with higher lift, but proportionately higher drag. Thus, the engines must provide enough thrust to overcome the drag from both the fuselage and the (now higher drag) wing.

[0006] In a blended wing configuration, on the other hand, both the fuselage and the wing provide lift. As the name implies, the blended wing blends the wing and fuselage together to provide a single, lift-producing body. In this configuration, the fuselage serves to both carry passengers and/or cargo and to provide a significant portion of the lift. As a result, the wing portion can be smaller for a given payload. Thus, blended wing aircraft tend to have significantly lower overall drag and can carry larger payloads while consuming less fuel.

[0007] Due to their unconventional shape, however, blended wing aircraft can present some challenges with regard to packaging. In other words, because the shape of the fuselage is more irregular than a conventional tube-shaped fuselage, providing storage for cargo, equipment, passengers, and other components can be challenging. In particular, as shown in FIGS. **1**A and **1**B, finding a suitable place to stow the retracted landing gear **105** can be challenging. In general, it is desirable to place the main, or rear, landing gear **105***a* fairly close to the center of gravity, C_G, of the aircraft. This placement reduces the aerodynamic forces that must be generated by the flight control surfaces **120** (e.g., elevons **110** and/or flaps **115**) to rotate the aircraft on take-off. In other words, if the main landing gear **105***a* is placed too far from the C_G, the flight surfaces cannot overcome the weight of the aircraft acting on such a large lever arm, L_{MG}, for the purposes of takeoff rotation.

[0008] As shown in FIG. **1**A, therefore, from a weights and balances standpoint, it is desirable to place the main gear **105***a* as close to the C_G as possible. In addition, the maximum width, or track, of the landing gear is limited by regulation to ensure landing gear/runway compatibility. In a blended wing design, however, this unfortunately places the landing gear in the middle of the desired passenger compartment (on a single level aircraft) or in the middle of the cargo compartment (on a multi-level aircraft). This reduces seating and/or cargo capacity and makes packaging, interior aesthetics, and utility more difficult, among other things.

[0009] As shown in FIGS. **2**A and **2**B, one solution is to simply move the main landing gear **105***a* rearward out of the passenger compartment **125**. Unfortunately, this places the main landing gear **105***a* at a substantial distance from the C_G. This, in turn, creates a large lever arm L_{MG}, between the C_G and the contact patch of the main landing gear **105***a*. In this configuration, the elevons **110** and/or flaps **115** are likely unable to generate enough negative lift at the rear of the wing to rotate the plane for takeoff. Thus, one problem—clearing the passenger and/or cargo compartment—has been traded for another—increasing takeoff distance or not being able to take off at all. Of the two, taking off is clearly more important in an aircraft.

[0010] What is needed, therefore, is a system and method for rotating the aircraft for takeoff using something other than the aerodynamic control surfaces. After takeoff, the location of the main landing gear **105***a* is relevant only to the overall weights and balances of the plane (e.g., center of lift, C_L vs C_G). The system should be simple and robust and provide pilots with a similar tactile experience as a conventional configuration. It is to such systems and methods to which examples of the present disclosure are primarily directed.

[0011] Examples of the present disclosure relate to a tilting, or rotating, landing gear system. The system enables an aircraft to be rotated about its center-of-gravity (C_G) regardless of the placement of the landing gear. In this configuration, the landing gear of the aircraft can be placed farther from the C_G than would otherwise be possible. The system provides a balanced hydraulic or mechanical system to reduce the effort required to rotate the aircraft to assume the desired angle-of-attack (AOA) for various procedures, such as takeoff, landing, ground operations, and other opera-

tional regimes. The system reduces the aerodynamic forces required by balancing mechanical and hydraulic forces about the C_G and can also include mechanical or hydraulic means in addition to the aerodynamic forces provided by the aerodynamic surfaces of the aircraft (e.g., ailerons, elevons, and/or flaps).

[0012] In some examples, the system can be a passive hydraulic system with hydraulic, pneumatic, or hydro-pneumatic cylinders mounted to the nose and main gears. The cylinders can be hydraulically connected such that an upward movement in a nose cylinder causes a proportional movement in two or more main cylinders, and vice versa. The cylinders can be balanced such that the hydraulic and mechanical forces (e.g., leverage) are balanced about the C_G, such that very little aerodynamic force is required to rotate the aircraft for takeoff.

[0013] In some examples, to achieve a positive AOA for takeoff, for example, a hydraulic valve between the main cylinder and nose cylinder can be opened. The cylinders can be sized such that, when the valve is in the open position with the aircraft on the ground, hydraulic fluid flows from the main cylinder(s) to the nose cylinder(s) causing the nose gear to extend and the main gear to squat. The relative position of the main gear(s) and the nose gear(s) can be locked by closing the hydraulic valve (i.e., when the desired AOA has been achieved). The system can include an AOA for landing, takeoff, ground operations, or maintenance, among other positions.

[0014] In flight, the valve can be opened and the weight of the main gear, for example, can cause the fluid to move from the nose cylinder back to the main cylinder. This extends the main gear and lowers the nose gear to a ground position, stowed position, or landing position, among other positions. During ground operations, the cylinders can be locked such that the aircraft is substantially level to the ground (i.e., the aircraft has a substantially zero AOA). In some examples, the system can also include a hydraulic pump to move hydraulic fluid from the nose cylinder to the main cylinder, and vice-versa.

[0015] Examples of the present disclosure can also include a control system and a method for mechanically rotating the aircraft during various procedures, such as take-off or landing. The control system can lock the aircraft in a substantially level attitude when on the ground (e.g., at a substantially zero AOA). When the aircraft reaches the appropriate speed and the pilot is pulling back on the control stick with at least a minimum force, the control system can open the hydraulic valve enabling the main gear to squat and the nose gear to extend to the desired AOA. This could include, for example, a rotation speed, or V_1, for takeoff, for example, or a reference speed, V_{REF}, for landing. The control system can close the hydraulic valve to lock the landing gear at the desired AOA. After takeoff, when the control system determines that the landing gear is unloaded—and the aircraft is airborne—the control system can close the valve to lock the landing gear in the position necessary for strut retraction. After landing, when the aircraft has sufficiently reduced its speed, the control system can close valve to lock the plane in a substantially level, ground position.

[0016] In an aspect, at least a nose gear disposed longitudinally forward of a center of gravity of an aircraft by a first distance and connected to a nose linkage configured to transfer movement from the at least a nose gear to at least a main gear and at least a main gear disposed longitudinally aft of the center of gravity of the aircraft by a second distance and connected to a main linkage configured to transform movement from the at least a main gear to the at least a nose gear. The at least a nose gear and the at least a main gear are mechanically linked.

[0017] In another aspect, A method of using a landing gear for an aircraft including disposing at least a nose gear forward of the center of gravity of an aircraft by a first distance, disposing at least a main gear aft of the neutral point of the aircraft by a second distance, and transferring movement between the at least a nose gear and the at least a main gear through a mechanical linkage between a nose linkage and a main linkage

BRIEF DESCRIPTION OF THE DRAWINGS

[0018] For the purpose of illustrating the invention, the drawings show aspects of one or more embodiments of the invention. However, it should be understood that the present invention is not limited to the precise arrangements and instrumentalities shown in the drawings, wherein:

[0019] FIGS. **1**A and **1**B are plan and side views, respectively, depicting a blended-wing aircraft with the landing gear in a convention location near the center-of-gravity (C_G) and inside the passenger or cargo compartment.

[0020] FIGS. **2**A and **2**B are plan and side views, respectively, depicting a blended-wing aircraft with the main landing gear in a rearward location farther from the C_G to improve packaging.

[0021] FIGS. **3**A and **3**B are side views depicting a blended-wing aircraft with the main landing gear in a rearward location with a tilting landing gear system in the level, or ground position (FIG. **3**A) and in the angle-of-attack (AOA)— e.g., takeoff or landing—position (FIG. **3**B), in accordance with some examples of the present disclosure.

[0022] FIGS. **4**A and **4**B are side views depicting a blended-wing aircraft with a direct-hydraulic tilting landing gear system in the level, or ground position (FIG. **4**A) and in the AOA position (FIG. **4**B), in accordance with some examples of the present disclosure.

[0023] FIGS. **5**A and **5**B are side views depicting a blended-wing aircraft with a lever-actuated tilting landing gear system in the level, or ground position (FIG. **5**A) and in the AOA position (FIG. **5**B), in accordance with some examples of the present disclosure.

[0024] FIG. **6**A is a side view depicting a blended-wing aircraft with a rearward pivoting swingarm landing gear system, in accordance with some examples of the present disclosure.

[0025] FIG. **6**B is a side view depicting a blended-wing aircraft with a forward pivoting, folding swingarm landing gear system, in accordance with some examples of the present disclosure.

[0026] FIG. **7**A is a front view depicting a landing gear with direct-linear actuators, in accordance with some examples of the present disclosure.

[0027] FIG. **7**B is a front view depicting a landing gear with linear actuators acting via a swingarm, in accordance with some examples of the present disclosure.

[0028] FIGS. **8**A and **8**B are front views depicting a telescoping landing gear in the extended position (FIG. **8**A) and the retracted, or collapsed, position (FIG. **8**B), in accordance with some examples of the present disclosure.

[0029] FIG. **9** is an exemplary embodiment of mechanically coupled landing gear

[0030] FIG. **10** is a side view of an embodiment of a mechanically coupled nose gear

[0031] FIG. **11** is a side view of an embodiment of a mechanically coupled main gear

[0032] FIG. **12** is a schematic diagram of a control system for the rotating landing gear system, in accordance with some examples of the present disclosure.

[0033] FIG. **13** is a flowchart depicting a method for passively controlling the rotating landing gear system on takeoff, in accordance with some examples of the present disclosure.

[0034] FIG. **14** is a flowchart depicting a method for actively controlling the rotating landing gear system on takeoff, in accordance with some examples of the present disclosure.

[0035] FIG. **15** is a flowchart depicting a method for controlling the rotating landing gear system on landing, in accordance with some examples of the present disclosure.

[0036] FIG. **16** is a flowchart depicting a method for using a mechanically coupled landing gear.

DETAILED DESCRIPTION

[0037] Examples of the present disclosure related generally to aircraft landing gear, and specifically aircraft landing gear that enables the aircraft to be tilted, or rotated, for takeoff or landing, for example, with very little force from the aircraft's aerodynamic control surfaces. In some examples, the system can include one or more interconnected hydraulic cylinders that enable the aircraft landing struts to extend in the front and collapse in the back to provide the desired takeoff or landing attitude. In some examples, the hydraulic cylinders can be sized and shaped to provide the desired first configuration on the ground and then return to the default, second configuration after takeoff. In other embodiments, the hydraulic cylinders can be linked to levers sized and shaped to provide the desired effect.

[0038] To simplify and clarify explanation, the disclosure is described herein as a system and method for use with a blended wing aircraft. One skilled in the art will recognize, however, that the disclosure is not so limited. While the system is useful in conjunction with blended wing aircraft due to some unique packaging constraints, it should be understood that the system can just as easily be used for conventional tube and wing, delta wing, and other aircraft configurations. The system can also be used as a safety measure to ensure takeoff or landing rotation in a plane that is, for example, malfunctioning or inadvertently misloaded. In addition, the system could also be used for ground-based equipment, such as loaders, semi-trucks, and other equipment that require tilting or rotation during use.

[0039] The manufacturing methods, materials, and systems described hereinafter as making up the various elements of the present disclosure are intended to be illustrative and not restrictive. Many suitable materials, struts, systems, and configurations that would perform the same or a similar function as the systems described herein are intended to be embraced within the scope of the disclosure. Such other systems and methods not described herein can include, but are not limited to, vehicles, systems, networks, materials, and technologies that are developed after the time of the development of the disclosure.

[0040] As discussed above, it is often convenient to place the main landing gear toward the rear of the aircraft for packaging purposes. This tends to move the landing gear behind the passenger and/or cargo compartments enabling more, or more convenient, passenger and cargo compartments. Unfortunately, this also tends to move the landing gear away from the C_G of the aircraft. This, in turn, increases the amount of force required to rotate the aircraft for takeoff or landing. This rearward landing gear configuration may require five times the force or more, to rotate the aircraft than can be produced by the aerodynamic surfaces of the wing at takeoff speeds. What is needed, therefore, is a system and method that assists, or replaces, the forces provided by the aerodynamic surfaces with mechanical forces of sufficient force.

[0041] To this end, as shown in FIGS. **3**A and **3**B, examples of the present disclosure can comprise a system **300** comprising a main gear **305** that can squat and/or a nose gear **310** that can extend to mechanically provide the desired angle-of-attack (AOA or a) for takeoff and/or landing. In some examples, the system **300** can comprise two or more main gears **305***a* and one or more nose gear **310**. In some examples, the system **300** can comprise standard oleo struts **315** (e.g., air-oil pneumatic struts) mounted on one or more actuators **320**. In some examples, as discussed below, the actuators **320** can be cylinders that are hydraulically or pneumatically linked, such that when one hydraulic cylinder **320** collapses the other hydraulic cylinder **320** extends, and vice-versa. In other examples, the hydraulic cylinder **320** can be independently controlled to work in concert. In a preferred embodiment, the hydraulic cylinder **320** can comprise hydraulic cylinders that are also hydraulically linked.

[0042] As shown in FIG. **3**A, therefore, in the level, or ground, configuration, the aircraft can be substantially level. In this configuration, the hydraulic cylinders **320** can be positioned such that the oleo struts **315** suspend the aircraft at a substantially level attitude with respect to the ground. This can enable passengers and cargo to be loaded onto the aircraft in the conventional manner. This can also enable the aircraft to be taxied for takeoff without unnecessarily affecting the pilot's view of the ground or adversely affecting ground handling. In other examples, the aircraft can have a slightly nose heavy configuration, for example, such that when the aircraft is on the ground, the nose hydraulic cylinder **320***b* is fully retracted and the main hydraulic cylinder **320***a* is fully extended. As discussed below, in some examples, for safety purposes, the hydraulic cylinders **320** can be locked in the level position anytime the aircraft is on the ground and below a predetermined speed unless otherwise overridden—e.g., for maintenance purposes.

[0043] As shown in FIG. **3**B, however, to enable the aircraft to rotate for takeoff or landing, the main hydraulic cylinder **320***a* can collapse and the nose hydraulic cylinder **320***b* can extend to provide the desired AOA. In this configuration, as with conventional landing gear, the oleo struts **315** react to impacts and undulations on the ground, but these motions are measured in inches, quite small relative to the stroke needed for the tilting system. As the hydraulic cylinders collapse and extend, however, the overall height of the strut/cylinder assembly **325** changes.

[0044] Thus, as the main hydraulic cylinder(s) **320***a* (i.e., two or more main hydraulic cylinder **320***a* for the two or more main gears **305***a*) retracts, the rear strut/cylinder assembly **325***a* squats. Conversely, as the nose hydraulic

cylinder **320***b* (i.e., the cylinder for the nose gear **310**) extends, the nose strut/cylinder assembly **325***b* extends. This has the effect of lowering the rear of the aircraft and raising the front of the aircraft to simulate takeoff rotation and/or landing flare.

[0045] Notably, however, this attitude is achieved with the landing gear **305**, **310** still on the ground. In addition, as discussed below, the location and size of the hydraulic cylinders **320** can be such that they are essentially in equilibrium about the C_G. In this manner, the system **300** can rotate the aircraft with very little force provided by the aerodynamic surfaces of the wing. This (1) overcomes the aforementioned issues related to overcoming a large L_{MG} and (2) does so with the wing in a more aerodynamically efficient configuration. Because rotation requires much less negative lift and thus, deflection of the elevons **110** (or elevons in a tailless configuration) and/or flaps **115**, the wing is also in a "cleaner" aerodynamic configuration (at least initially). In other words, significantly less negative lift is required at the back of the wing to generate the rotation moment, enabling the wing to provide greater positive lift for takeoff. This, in turn, can reduce takeoff speed, and therefore takeoff distance.

[0046] Upon takeoff, once the main gear **305** has cleared the tarmac, the location of the main gear **305** is no longer relevant from an aerodynamic standpoint. Once aloft, the location of the main gear **305** is relevant only from a weights and balances standpoint, which can be accounted for with fuel, cargo, and/or passenger weight, among other things. At or before liftoff, therefore, the flight control surfaces **120** can be positioned to provide the necessary aerodynamic forces to maintain the desired AOA for climb out.

[0047] Of course, while shown and described with hydraulic cylinders **320**, pneumatic cylinders and other types of linear or rotary actuators could be used. The system **300** could utilize linear actuators, for example, electrically driven by the aircraft's electrical system. The system **300** could also utilize servo motors, for example, with a rack and pinion or pushrod actuation to the landing gear **305**, **310**. Indeed, rather than using separate hydraulic cylinders **320**, as shown, the system **300** could use lengthened versions of the existing oleo struts **315** interconnected in a similar manner. This configuration might reduce weight and complexity if sufficient space is available in the airplane for the lengthy struts **315** and the volume swept by the rotation angle needed for retraction. Thus, any type of mechanism that can enable the main gear **305** to squat and/or the nose gear **310** to lift can provide the necessary AOA.

[0048] As shown in FIGS. **4**A and **4**B, in some examples, the system **400** can be essentially passive. In this configuration, the hydraulic cylinders **320** can be linked and can be sized and shaped such that they are essentially hydraulically neutral about the C_G. In other words, the total area of the piston(s) for the nose hydraulic cylinder **320***b* and the total area of the piston(s) for the main hydraulic cylinder **320***a* combined with their relative distances from the C_G can be calculated to balance the aircraft about the C_G.

[0049] As shown, in some examples, the main hydraulic cylinder **320***a* can have a larger total piston surface area, A_{MG}, (i.e., the combined, or total, piston surface area of the main hydraulic cylinders **320***a*, if there are multiple main gears **305***a*) than the total piston surface area, A_{NG}, of the nose hydraulic cylinder **320***b*. In the configuration, the distance, L_{NG}, from the nose gear **310** to the C_G can be larger than the distance, L_{MG}, from the main gear **305** to the C_G to produce hydro-mechanical equilibrium. Thus, in Equation 1:

$$A_{NG} = \frac{A_{MG}}{\frac{L_{NG}}{L_{MG}}}$$

So, for example, if $L_{NG}=3\times L_{MG}$, then the $A_{NG}=1/3\ A_{MG}$ (from 1, $A_{NG}=A_{MG}/3$). The hydraulic cylinders **320** can also be linked with a suitably sized hydraulic pipe **405** (e.g., a pipe or hose).

[0050] This system allows very small force to rotate the aircraft about its C_G despite the placement of the landing gear **305**, **310** farther from the C_G. In other words, by balancing the hydraulic forces between the nose hydraulic cylinder(s) **320***b* and the main hydraulic cylinder(s) **320***a*, a virtual pivot about the C_G is created. Thus, a small downward force at the rear of the wing from the flight control surfaces **120** can cause the aircraft to rotate for takeoff. Similarly, a small braking force from the aircraft's brakes can cause the aircraft to de-rotate from the landing position to the ground position, for example.

[0051] In some examples, it may be desirable to include a hydraulic valve **410** between the hydraulic cylinders **320**. In this manner, the hydraulic cylinders **320** can be locked in a particular position. The hydraulic valve **410** can be, for example, a ball valve, gate valve, or throttle valve.

[0052] In the level, or ground position, therefore, both hydraulic cylinders **320** can be positioned such that the oleo struts **315** are in substantially the same position and the aircraft fuselage is substantially level. In some examples, the aircraft may have a very slightly nose heavy configuration. This can be achieved passively with the difference in deadweight of the landing gear, for example, or by using a small pump **435** to provide a slight bias of fluid to the main hydraulic cylinder **320***a*. When the hydraulic valve **410** is open (or there is no hydraulic valve), therefore, the nose hydraulic cylinder **320***b* can retract and the main hydraulic cylinder **320***a* can extend. In some examples, the aircraft can be in the ground position when the nose hydraulic cylinder **320***b* is completely retracted, or "bottomed out."

[0053] As shown in FIG. **4**B, to achieve the desired AOA, the nose hydraulic cylinder **320***b* can be extended and the main hydraulic cylinder **320***a* can be retracted. This can be achieved in a number of ways. Since the system **400** is balanced about the C_G, for example, a small downward force from the flight control surfaces **120** can cause the aircraft to rotate about the C_G to the AOA position.

[0054] If a hydraulic valve **410** is included, the hydraulic valve **410** can first be placed in the open position. Because the aircraft is in equilibrium, however, opening the hydraulic valve **410** does not, in itself, create any rotation. As before, the rotation can be provided by small forces provided by the flight control surfaces **120**. In some examples, the aforementioned pump **435** can be reversed to cause fluid to flow from the main hydraulic cylinder **320***a* to the nose hydraulic cylinder **320***b*. This, in turn, causes the main gear **305** to squat and the nose landing gear **130** to extend creating the desired AOA. In any configuration (i.e., with or without a hydraulic valve **410** or a pump **435**), the amount of energy required to cause the rotation is significantly smaller because the aircraft is essentially balanced about the C_G.

[0055] As discussed below, in some examples, the system **400** can include a control system to control the position of the hydraulic cylinders. In some examples, the system **400** can comprise one or more sensors to detect the AOA. In some examples, the system **400** can include a tilt sensor **420** disposed on the aircraft to detect the AOA. In some examples, the tilt sensor **420** can comprise the attitude sensor included in the aircraft's exiting avionics package. In other examples, the tilt sensor **420** can comprise a separate gyro, accelerometer, or similar sensor to detect the AOA. In other examples, the system **400** can include one or more position sensors **425** located on the hydraulic cylinders **320**. Based on the position of the hydraulic cylinders **320** and the geometry of the system, the AOA can be calculated.

[0056] In still other examples, the system **400** can include one or more switches **430** located on the hydraulic cylinders **320**. In this configuration, the system **400** can simply comprise two or more positions for various flight situations. The system **400** can include one switch **430***a* for each cylinder in the ground position (FIG. **4**A), for example, and one switch **430***b* on each cylinder for the takeoff position (FIG. **4**B). The system **400** can also comprise additional switches for additional positions (e.g., landing, heavy payload, etc.).

[0057] In some examples, the system **400** can be completely passive. In other words, in some examples, the system **400** can move from the ground position (FIG. **4**A) to the takeoff position (FIG. **4**B) based solely on the small aerodynamic force provided by the flight control surfaces **120**. Similarly, after takeoff, the system **400** can move back to the ground position, for example, because the total weight of the main gear **305** is generally significantly heavier than the total weight of the nose gear **310**. After takeoff, therefore, the hydraulic valve **410** can remain open (or be reopened) to enable the total weight of the main gear **305** to extend the main hydraulic cylinder **320***a* and compress the nose hydraulic cylinder **320***b* back to the level position. In other examples, as discussed below, hydraulic pumps, motors, or other power assist can be used.

[0058] As mentioned, the system **400** can also comprise a hydraulic motor or pump **435**. The pump **435** can be used to actively reposition the landing gear **305**, **310** despite loading. In other words, in some examples, it may be desirable to raise the nose gear **310** despite the fact that the aircraft is in a nose heavy configuration. In this configuration, opening the hydraulic valve **410** may cause the nose hydraulic cylinder **320***b* to collapse. In this case, the pump **435** can be activated to provide the desired forward pressure. In some examples, the pump **435** can be reversible, enabling it to pump fluid in either direction to affect rotation in either direction (e.g., nose up/mains down and nose down/mains up). In some examples, the pump **435** can be activated only when the system **400** determines that the landing gear **305**, **310** is not moving in the desired direction.

[0059] In addition to providing equilibrium about the C_G, the different relative sizing of the hydraulic cylinders **320** also cause a proportionally different stroke, S, for each of the cylinders. This relationship is given in Equation 2:

$$\frac{L_{NG}}{L_{MG}} = \frac{S_{NG}}{S_{MG}}$$

[0060] In other examples, as shown in FIGS. **5**A and **5**B, the hydraulic cylinders **505** can be augmented with levers **510** to provide the desired effect. In other words, in some examples, as shown in FIGS. **5**A and **5**B, the levers **510** can be used to increase the travel of the nose gear **310** or main gear **305** to enable a smaller (shorter) hydraulic cylinder **505** to be used. Thus, while the main gear **305** may be substantially in line with the rear hydraulic cylinder **505***a*, the nose gear **310** may be offset from the front hydraulic cylinder **505***b* with a nose gear lever **510***b*. In this manner, a relatively small movement of the front hydraulic cylinder **505***b* results in a larger movement of the nose gear **310**. Thus, a hydraulic cylinder **505** with a shorter stroke can be used, if desired, for packaging, weight, or other reasons.

[0061] In some examples, the mechanical advantage/disadvantage of the levers **510** can also be used to adjust the equilibrium between the front hydraulic cylinder **505***b* and rear hydraulic cylinder(s) **505***a*. As shown in FIG. **5**A, the rear hydraulic cylinder **505***a* acts substantially directly on the main gear **305**, while the front hydraulic cylinder **505***b* acts on the nose gear **310** via the nose gear lever **510***b* at a distance L_{NG}. In this configuration, the nose gear **310** travels farther than the main gear **305** for a given hydraulic cylinder **505** stroke, but also is acted upon with less force. This can serve to distribute the forces appropriately based on the fact that the nose gear **310** generally carries less weight than the main gear **305**.

[0062] This can also enable the same size hydraulic cylinder **505** to be used for both the nose gear **310** and the main gear **305**. Because the rear hydraulic cylinder **505***a* acts substantially directly on the main gear **305**, while the front hydraulic cylinder **505***b* acts via a lever arm, $L_{NG\text{-}MOUNT}$/$L_{PISTON\text{-}MOUNT}$, the same size hydraulic cylinder **505** can be used to provide hydraulic equilibrium. In other words, the mechanical advantage provided by the distance from the nose gear to the C_G, L_{NG}, is offset by the mechanical disadvantage of the nose gear lever **510***b*. This relationship is given in Equation 3:

$$A_{NG} = A_{MG}$$

$$\frac{L_{NG-MOUNT}}{L_{PISTONMOUNT}} = \frac{L_{NG}}{L_{MG}} = \frac{S_{NG}}{S_{MG}}$$

Thus, if we once again assume that $L_{NG}=3\times L_{MG}$, but that the hydraulic cylinders **505** have the same total area, then $L_{NG\text{-}MOUNT}/L_{PISTON\text{-}MOUNT}=3$ provides hydro-mechanical equilibrium. This approach allows all of the tilting hydraulic cylinders to be identical for lower cost.

[0063] Of course, the linkages for the landing gear can take many forms. As shown in FIG. **6**A, for example, the nose gear **310** can be mounted on a rear-swinging swingarm **605**. As discussed above, this can enable the nose hydraulic cylinder **320***b* to have a shorter stroke, while providing sufficient travel for the nose gear **310**. As shown, the nose gear **310** can have at least three positions. In the first position, ①, the rear-swinging swingarm **605** is in the fully retracted position. In this position, the nose gear **310** is fully retracted inside the fuselage to enable the landing gear doors to be closed, for example. In the second, or intermediate position, ②, the rear-swinging swingarm **605** is in substantially the same position, but the nose gear **310** is rotated to a position that supports the fuselage such that it is substan-

tially level with the ground. This can be referred to as the "ground position" in that it can enable the aircraft to taxi and to be loaded and unloaded in the convention manner.

[0064] In the third position, ③, or AOA position, the rear-swinging swingarm **605** (and thus, the nose gear **310**) can be lowered to raise the nose of the aircraft to create the desired AOA. As discussed above, the AOA position can be used to place the aircraft in the proper configuration for takeoff, for example, while requiring very little force to be supplied by the aerodynamic surfaces (e.g., only enough to upset the equilibrium). In this manner, the aircraft can be rotated for takeoff, for example, despite there being a large distance (and a resulting large moment) between the landing gear and the C_G.

[0065] In some examples, the high AOA position can also be used for landing. For most aircraft, lowering the nose as quickly as possible reduces landing distance. However, for some aircraft holding the nose at high AOA adds drag to reduce landing distance. In this instance, the nose gear **310** can be placed in the high AOA position prior to landing such that, when the nose gear **310** touches down, the aircraft maintains the high angle for deceleration. The aircraft can then be slowly rotated to the ground position during deceleration. In some examples, the force required to cause the (de)rotation on landing can be provided by the aircraft's braking system.

[0066] In some examples, the hydraulic pipe **405** can be sized and/or can include an orifice, to provide the desired rotation rate. In other words, the hydraulic pipe **405** can include a restriction to prevent the nose gear **310** from collapsing in an uncontrolled manner. In some examples, the system **500** can include a pump **435** to provide a slight forward bias. In the manner, the nose gear **310** can maintain the AOA position until overcome by braking forces. At this point, the pump **435** can be turned off or reversed to enable the system **500** to rotate back to the ground position.

[0067] In some examples, the AOA position for landing and takeoff can place the fuselage at the same AOA. In other examples, the AOA position can comprise at least two different positions—a landing AOA position and a takeoff AOA position.

[0068] As shown in FIG. **6**B, in some examples, the system can include a forward-swinging swingarm **610**. Similar to the rear-swinging swingarm **605**, the forward-swinging swingarm **610** can enable a shorter stroke nose hydraulic cylinder **320***b* to be used. In addition, in some examples, the forward-swinging swingarm **610** can include an additional pivot **615** to enable the oleo strut **315** to be folded when in the first position, ①. In this manner, the nose gear **310** can be stowed in a smaller space when in the first position. As before, the forward-swinging swingarm **610** can also comprise a ground position, ②, for taxiing and ground operations, and an AOA position, ③, for takeoff and/or landing.

[0069] As before, regardless of the nose gear **310** configuration, in addition to raising the nose, the main gear **305** can also squat to provide additional rotation by simply collapsing the main hydraulic cylinder **320***a*. In the ground position, on the other hand, the main hydraulic cylinder **320***a* can be raised to place the aircraft in a substantially level position with respect to the ground.

[0070] As shown in FIG. **7**A, the nose gear **310** or main gear **305** can be mounted to the hydraulic cylinders **320** in a substantially linear manner. In other words, in some examples, the oleo strut **315** can be mounted directly to the hydraulic cylinders **320** using a brace **705**, for example, or other suitable means. In this configuration, extension or retraction of the hydraulic cylinders **320** results in the same extension or retraction of the landing gear **305**, **310**. This can enable the system to be relatively simple, compact, lightweight, and robust.

[0071] In other examples, as shown in FIG. **7**B, the nose gear **310** or main gear **305** can be mounted to the hydraulic cylinders **320** via the forward **610** or rearward **605** pivoting swingarm. In other words, in some examples, the oleo strut **315** for either landing gear **305**, **310** can be mounted to the hydraulic cylinders **320** via the forward **610** or rearward **605** pivoting swingarm using a brace **705**, for example, or other suitable means. In this configuration, extension or retraction of the hydraulic cylinders **320** can create a proportionately larger extension or retraction of the landing gear **305**, **310**. This can enable the hydraulic cylinders **320** to be shorter for a given landing gear **305**, **310** travel, which can improve packaging. In addition, as discussed above, the swingarm may include additional pivots to enable the landing gear **305**, **310** to fold when retracted. This can enable the landing gear **305**, **310** to be stowed more compactly when retracted in flight.

[0072] In still other examples, as shown in FIGS. **8**A and **8**B, the system can include a telescoping strut mount **805**. In this configuration, the oleo strut **315** and landing gear **305**, **310** can be mounted to the telescoping strut mount **805**. The telescoping strut mount **805**, in turn, can be moved between a first, extended position (FIG. **8**A) and a second, retracted position (FIG. **8**B). Thus, the telescoping strut mount **805** can place the aircraft in the AOA position at or near the first position and can place the aircraft in the ground position at or near the second position. In some examples, the ground position can be in between the first position and the second position. In this configuration, the first, fully retracted position may enable the nose gear **310** to squat for service, loading, or other reasons (i.e., the second position may be below the ground position).

[0073] In other examples, and as shown in FIG. **9**, the system may include mechanically linked gears. In this configuration, main gear **305** and nose gear **310** may be linked by a mechanical connection. As used in the current disclosure, "mechanically connected" is when the fore and the aft landing gear (nose and main landing gear, respectively) are configured to move along the vertical axis in tandem. As used herein, "in tandem" means that the main gear and the nose gear work together, such that one affects the other. In embodiments, when the pair of aft landing gear rises the fore landing gear may be lowered. In other embodiments, when the fore landing gear rises the aft landing gear may lower. There may be two main gears and one nose gear to form a tricycle arrangement. As used herein, a "tricycle arrangement" is an arrangement where in at least 3 components form a triangular shape. Alternatively, a tricycle formation may include two nose gears and one main gear **305**. Alternatively, landing gear may be in a bicycle formation. As used herein, a "bicycle formation" is an arrangement wherein at least two components that are nearly or directly behind each other. In this embodiment, the nose gears and main gears may be located on or close to the aircraft's centerline. Furthermore, there may be one or more struts located ahead of the aircraft's neutral point, and one or more struts located aft of the neutral point. There may be addi-

tional minor landing gear located outward from the centerline to provide stability to the aircraft. There may be more than one wheel attached to each gear assembly, such as the nose gear **310** and the main gear **305**. In an embodiment, the system may be in a quadracycle formation. As used herein, a "quadracycle formation" is an arrangement wherein at least 4 components form a rectangular shape. For example, there may be two nose gears and two main gears positioned such that the four gears form a rectangular shape, much like the four wheels of a car.

[0074] Still referencing FIG. **9**, nose gear **310** may include a nose wheel **905**. As used in this disclosure, "nose wheel" is a wheel component within a nose gear landing gear assembly that is configured to make contact with and roll on the ground. Wheel may include a pneumatic tire, or the like. A tire may be composed at least in part of an elastomeric material such as rubber. An aircraft tire may include an interior lumen or sealed chamber, which may also be annular, and which may be filled with pressurized gas to increase the tire's resistance to elastic deformation, permitting it to bear greater weight without allowing the rim to contact the ground. Aircraft tire may be capable of being exposed to temperatures below −40° C. and/or above 200° C. without losing elasticity or integrity. Aircraft tires may be composed of, without limitation rubber, nylon, cord, and/or steel. Aircraft tires may include a tire tread pattern. As used in this disclosure a "tire tread pattern" is a circumferential groove molded into the rubber of the tire to improve traction. For example, and without limitation, a tire tread pattern may be composed of 4 circumferential grooves molded into the aircraft tire to channel water away from the tire surface. In an embodiment and without limitation, tire tread patterns may be designed to maximize the amount of rubber making contact with the ground to decrease the landing distance and/or enhance braking performance. Nose gear **310** may be connected to a nose linkage **910**. A nose linkage **910** may be a sector, gear, cam, or the like, that helps translate motion from one gear to another. As used herein, a "sector" is a partial pully that provides extension to a system. A sector may be composed of materials such as aluminum, steel, polycarbonate, carbon fiber, fiber glass, or the like. A sector may act as a cam, such that it creates a relationship between cable motion of a main cable, as discussed below, and rotary motion of a shaft, such as a lateral shaft as discussed below. In an embodiment, compression of oleo struts **315** attached to a nose wheel **905** may translate to the nose linkage **910** such that it provides extension to a main gear **305**. In another embodiment, nose linkage **910** may transfer the movement of a main gear **305** to movement of the nose wheel **905**.

[0075] Continuing to reference FIG. **9**, Main gear **305** may be coupled to a lateral shaft **915**. Lateral shaft may be a torque tube. A "torque tube" as used herein, transmits force by torsion. A main linkage **920** may be located on the lateral shaft **915**. Main linkage **920** may be located at the center of the lateral shaft **915**. Main linkage **920** may be located partially off center of the lateral shaft **915**. Main linkage **920** may transform movement of the lateral shaft **915** into movement of the nose gear **310**. Main linkage **920** may include a sector, cam, gear, or the like. Lateral shaft may receive movement from main gear **305**. Alternatively, or additionally, main linkage **920** may transform movement of nose gear **310** to movement of main gear **305**.

[0076] Continuing to reference FIG. **1**, main linkage **920** and nose linkage **910** may be connected by a longitudinal member **925**. Longitudinal member **925** may be a tension cable. A "tension cable," as used herein, is one or more ropes, wires, or the like, that are in tension. Tension cables may be made of steel wires, or other metal wires. Tension cable may be wrapped in a sheath of plastic. Longitudinal member may be a bar, tube, chain, belt, or the like, that translates movement from sector to another. Longitudinal member **925** may run down the centerline of the aircraft, longitudinally. Longitudinal member **925** may be a plurality of cables, such as a dual set of cables on opposite sides of the aircraft's centerline. Longitudinal member **925** may be driven by the main linkage **920** and/or the nose linkage **910** such that movement from one linkage may be translated through the longitudinal member **925** and affect the other linkage. Longitudinal member **925** may be a continuous loop of cables that engage through the main linkage **920** and the nose linkage **910**. Longitudinal member **925** may be the "rope" that threads through the partial pulleys. Longitudinal member **925** may be composed of materials such as KEVLAR, TECHNORA, VECTRAN, and/or SPECTRA. Longitudinal member **925** may also be composed of metals such as steel, aluminum, titanium, or the like. Longitudinal member **925** may accommodate differential thermal expansion between the cable and an airframe of the aircraft.

[0077] Now referencing FIG. **10**, an embodiment **1000** of a nose gear **310** on an aircraft is shown. Nose gear **310** may include oleo struts **315**. oleo struts **315** may be mechanically connected to a nose wheel **905**. oleo struts **315** may include a pneumatic shock absorber that may include air or oil. oleo struts **315** may include a cylinder and a piston to act as a damper/shock absorber. oleo struts **315** may be passive, such that no computing device or external sources are necessary to dampen an impact on oleo struts **315**. Oleo struts are discussed in further detail above.

[0078] Continuing to reference FIG. **10**, nose gear **310** may include a pivot piston **208**. A "pivot piston" as used herein, translates vertical movement into lateral movement. A pivot piston may include a rotating rod. Pivot piston **208** may be mechanically connected to the nose linkage **910** and the oleo struts **315** and nose wheel **905**. In an embodiment, movement in the nose wheel may compress the oleo struts **315** which may cause the pivot piston **208** to rotate the nose linkage **910**. As a result, the nose linkage **910** may pull the longitudinal member **925**, affecting the main gear on the other end of the longitudinal member **925**. Pivot piston **208** may be hydraulic, pneumatic or the like. Pivot piston **208** may be similar to actuators **320**, as discussed above.

[0079] Now referencing FIG. **11**, an embodiment **1100** of a main gear **305** on an aircraft is shown. Main gear **305** may include oleo struts **315**. oleo struts **315** may be mechanically connected to a main wheel **930**. oleo struts **315** may be consistent with any suspension/oleo struts **315** as discussed above. Main gear **305** may include a lateral shaft **915**, as discussed above, that may be connected to two main gears. Lateral shaft may have torsional rigidity to provide resistance to an airplane roll. In an embodiment, an uneven force may be applied to main wheels in a tricycle formation. Lateral shaft **915** may stabilize the aircraft to prevent the aircraft from rolling due to the uneven forces. Lateral shaft may be composed of materials with torsional rigidity and shear strength, such as metals like steel or aluminum.

[0080] Continuing to reference FIG. **11**, main gear **305** may include a main linkage **920**. Main linkage **920** may be connected to lateral shaft **915**, as discussed above. Main

linkage **920** may be mechanically connected to the longitudinal member **925**, such that the cable and the main linkage **920** are coupled.

[0081] In an example, without limitation, and referring to FIG. **10** and FIG. **11**, main gear **305** may compress during takeoff. The compression of oleo struts **315** may create torsion in the lateral shaft **915**. The lateral shaft **915** may be coupled to the main linkage **920**. The main linkage **920** may rotate, as a result of the torsion in the lateral shaft **915**, to pull the longitudinal member **925** towards the aft of the aircraft (to the right in FIG. **3**), creating tension in the longitudinal member **925**. As a result, the nose linkage **910** may be pulled by the longitudinal member **925** in the direction towards the aft of the aircraft (to the right in FIG. **2**). The nose linkage **910** may expand/extend the pivot piston **208**, which extends the nose oleo struts **315**. This may increase the angle of attack of the aircraft as the nose gear **310** is lengthened and the main gear **305** is compressed. The opposite may happen such that the main gear **305** may extend and the nose gear **310** may compress.

[0082] Examples of the present disclosure can also comprise a system **1200** for monitoring and controlling the position of the landing gear. The system **1200** can include a controller **1205** for receiving inputs and providing outputs to control the position of the landing gear. The controller **1205** can comprise, for example, a dedicated microcontroller, a laptop or desktop computer, a module, an integrated circuit, or other suitable electronic device. The controller **1205** can include a processor, one or more types of memory, and one or more communication buses for connection to aircraft systems, sensors, and or actuators.

[0083] The system **1200** can also include one or more sensors to provide information to the controller **1205**. The system **1200** can include, for example, a ground speed indicator **1210**, and airspeed indicator **1215**, and a stick force sensor **1220**. The system **1200** can also include a hydraulic valve position sensor **1225**, a hydraulic pressure sensor **1230**, a nose gear position sensor **1235**, a main gear position sensor **1240**, and a strut load sensor **1245**.

[0084] As the names imply, the ground speed indicator **1210** and air speed indicator **1215** provide the velocity of the aircraft with respect to the ground and the air, respectively. In some examples, the ground speed indicator **1210** can comprise a mechanical or electronic speedometer mounted to the landing gear **305**, **310**. In other examples, the ground speed indicator **1210** can be provided by GPS, LORAN, or other suitable means. The air speed indicator **1215** can comprise a pitot tube, or other suitable pressure measurement device. In some examples, the system **1200** can use a standalone ground speed indicator **1210** and air speed indicator **1215**. In other examples, this information can be provided by existing avionics already installed on the aircraft.

[0085] In order to prevent the landing gear **305**, **310** from rotating at inopportune times, the system **1200** can prevent rotation until certain conditions are met. One possible condition is that the aircraft is at, or near, the proper rotation speed, or V_1, for example, or a proper, or reference, landing speed, V_{REF}. A second possible condition is that the pilot is requesting the rotation. To this end, the system **1200** can also include a stick force sensor **1220**. As the name implies, the stick force sensor **1220** can measure the input of the pilot on the flight control stick or yoke. Thus, when the force applied by the pilot rearward on the stick ("pulling up" in the stick) reaches a predetermined force, the controller **1205** can initiate the landing gear rotation.

[0086] In some examples, such as in a system with active hydraulics (discussed above), the system **1200** can also include a hydraulic pressure sensor **1230**. This can ensure that the landing gear **305**, **310** remains locked unless and until there is sufficient pressure to affect the desired rotation. Of course, in a passive system, the hydraulic pressure sensor **1230** may serve only to ensure there is not a pressure leak, or other failure.

[0087] The system **1200** can also include one or more nose gear position sensors **1235** and main gear position sensors **1240**. The position sensors **1235**, **1240** can determine that the landing gear **305**, **310** is initially in the ground position, for example. The position sensors **1235**, **1240** can also determine when the landing gear **305**, **310** is in the AOA position for takeoff and/or landing. As discussed below, the controller **1205** can close the hydraulic valve to lock the landing gear **305**, **310** in a particular position, based on feedback from the position sensors **1235**, **1240**. The positions sensors **1235**, **1240** can comprise, for example, capacitive displacement sensors, piezo-electric transducers, potentiometers, proximity sensors (e.g., optical), or rotary encoders (e.g., angular). The position sensors **1235**, **1240** can be linear and can be mounted directly on the hydraulic cylinders **320**, for example, or can be rotary and can be connected to the hydraulic cylinders **320** or landing gear **305**, **310** via pivoting arms.

[0088] The system **1200** can also include a strut load sensor **1245**. The strut load sensor **1245** can measure the load, or position, of the oleo strut **315**. Thus, on takeoff or landing, the landing gear **305**, **310** can be locked in position based on whether the oleo strut **315** is loaded (on the ground) or not. On takeoff, the landing gear **305**, **310** can be locked in the AOA position, for example, until the strut load sensor **1245** determines that the nose gear **310**, main gear **305**, or both has been unloaded indicating the aircraft is airborne. At this point, the system **1200** can open the hydraulic valve **410**, for example, to return the landing gear **305**, **310** to the desired position (e.g., the ground position). The controller **1205** can also enable the landing gear **305**, **310** to be folded to the stowed, in-flight position.

[0089] The controller **1205** can also provide outputs to control the system **1200**. The controller **1205** can send the appropriate signal to the hydraulic valve **410**, for example, to open **1250** or close **1255** based on the inputs from the various sensors. If the controller **1205** determines that (1) the ground speed indicator **1210** indicates the aircraft is at or near V_1 and (2) the stick force sensor **1220** indicates that the pilot is applying a predetermined amount of rearward force on the stick (e.g., 5-10 lbs.), then the controller **1205** can send a signal **1250** to open the hydraulic valve **410**.

[0090] The hydraulic valve **410** enables hydraulic fluid to flow from the main hydraulic cylinder **320***a* to the nose hydraulic cylinder **320***b*. This enables the main gear **305** to squat and the nose gear **310** to raise to achieve the AOA position.

[0091] When the strut load sensor **1245** indicates that the nose gear **310**, the main gear **305**, or both have left the tarmac, the controller **1205** can send a signal **1250** to reposition the landing gear **305**, **310** to the appropriate position, after which the hydraulic valve **410** can be closed locking the gear in the proper position for retraction. As discussed above, in some examples, the weight of the main

gear **305** hanging down can enable the main gear **305** to re-extend from the AOA position and the nose gear **310** to retract.

[0092] In some examples, a hydraulic motor or pump **435** can be used to facilitate or expedite movement of hydraulic fluid between the hydraulic cylinders **320**. In this configuration, in addition to sending a signal to open **1250** and close **1255** the hydraulic valve **410**, the controller **1205** can also send a signal to start **1260** and stop **1265** the pump **435**. The pump **435** can enable the hydraulic cylinders **320** to be repositioned regardless of conditions such as, for example, weight destruction, aircraft attitude, and strut loading.

[0093] Examples of the present disclosure can also include a methods **1300**, **1400** for mechanically rotating an aircraft for various procedures (e.g., takeoff, taxiing, and/or landing). In some examples, as mentioned above, the system **500** can be substantially passive, relying on weights and balances combined with mechanical and/or hydraulic forces to essentially "balance" the aircraft on the landing gear. In other configurations, the system **400** can use pumps **435** and/or hydraulic valves **410** to actively move and control the aircraft.

[0094] In the "passive" configuration, the method **1300** can rely on the mechanical and hydraulic layout to effect movement of the aircraft. At **1305**, as in a convention aircraft, takeoff can begin with the engines being throttled up to the takeoff power setting. In a conventional aircraft, the pilot can simply pull back on the stick during the takeoff roll. When the aircraft reaches a predetermined velocity, or V_1, the velocity of the plane will be such that the aerodynamic surfaces of the aircraft rotate the nose of the aircraft into the air about the main gear.

[0095] As discussed above, in a blended wing configuration with a rearward main gear **305** placement, for example, the flight control surfaces **120** would normally be unable to create sufficient force to affect rotation. This is due in part to the longer distance between the main gear **305** and the C_G (e.g., as shown in FIGS. **2**A and **2**B). As discussed above, due to the hydraulic equilibrium created by the size, shape, and positioning of the hydraulic cylinders **320**, however, rotation about the C_G can be provided with very little force from the flight control surfaces **120**.

[0096] To this end, as the aircraft accelerates, at **1310** the pilot can apply rearward pressure on the stick to deflect the elevons **110** (or elevons, as the case may be). At **1315**, when the aircraft reaches the speed at which the aerodynamic forces overcome the inertial of the aircraft, the aircraft can rotate about the C_G to the AOA for takeoff, AOA_{TO}. As discussed above, because the aircraft is essentially in equilibrium on the ground, very little force is required for the aircraft to rotate.

[0097] As a result, the "Minimum Unstick Speed" (VMU) can be low enough that it is not the critical condition for establishing Takeoff Decision Speed (V_1). As a result, V**1** will generally be a substantially lower speed than would be required with conventional landing gear for any aircraft configuration (e.g., tube and wing vs. blended wing). Indeed, in the blended wing configuration, the force can be reduced from a level that cannot practically be generated using aerodynamics to a force that is lower than is currently required in a conventional tube and wing configuration. This can also significantly improve takeoff distances and climb out because the negative lift that the flight control surfaces **120** create—that the wing must counteract for liftoff—is substantially reduced.

[0098] At **9200**, when the aircraft reaches the minimum unstick speed, or V_{MU}, the aircraft will takeoff. As mentioned above, because very little force is required to rotate the aircraft, the amount of lift required to overcome the negative lift created by the elevons **110** and lift the aircraft is reduced. As a result, V_{MU}, takeoff roll, and fuel consumption, among other things, can be reduced.

[0099] At **9205**, the landing gear **305**, **310** can move to another position, such as the ground position. In some examples, the main gear **305** can be heavier than the nose gear **310**. When the aircraft takes off, therefore, the weight of the main gear **305** can cause the main hydraulic cylinder **320***a* to extend and the nose hydraulic cylinder **320***b* to retract. In some examples, the ground position can occur when the main gear **305** extends completely (i.e., to the "stops") and the nose gear **310** retracts completely. In this configuration, the landing gear **305**, **310** naturally and passively returns to the ground position in the air. Of course, the landing gear **305**, **310** could also be configured to return to a landing AOA position or a stowed position (e.g., the position in which the landing gear **305**, **310** takes up the minimum amount of space when retracted).

[0100] At **1330**, regardless of the position the landing gear **305**, **310** returns to (e.g., ground position, landing AOA position, stowed position, etc.), once the landing gear **305**, **310** has reached the desired position, the landing gear **305**, **310** can be retracted for flight. In the passive configuration, no valves or pumps are required for takeoff and all aircraft and landing gear **305**, **310** positioning is provided either by aerodynamic forces or by the relative weights of the landing gear **305**, **310**. This passive system reduces the complexity of the system, which can reduce weight, cost, and maintenance, among other things.

[0101] In some examples, a more active approach may be desired. In the "active" configuration, therefore, at **1405**, takeoff can once again begin with the engines being throttled up to the takeoff power setting. At **1410**, the system can then monitor the ground speed until the velocity of the aircraft, V, is at or near the velocity at which the aircraft would normally rotate for takeoff, V_R (e.g., V_R is approximately V_1-10 knots). Once this velocity is attained, at **1415**, the system can then determine if the pilot is pulling back on the stick with at least a minimum stick force, effectively requesting rotation of the aircraft into the AOA_{TO} position. At **1420**, if both conditions are met—i.e., $V \geq V_1$ and $F_{STICK} \geq F_{MIN}$— then the system can open the hydraulic valve **410** to enable the aircraft to rotate to AOA_{TO}.

[0102] At **1425**, the system can determine if the aircraft has achieved the desired AOA. The AOA may vary based on, for example, whether the aircraft is landing or taking off, temperature, humidity, and takeoff weight, among other things. As discussed above, the AOA can be measured using an accelerometer, gyro, or the onboard flight systems.

[0103] In some examples, as discussed above, the AOA can be a function of system geometry. In this configuration, the system **300**, **400** can forgo the hydraulic valve **410**, or the hydraulic valve **410** can remain in the open position. In other examples, it may be desirable to hydraulically lock the aircraft at a particular AOA based on takeoff weight, weather

conditions, etc. In this configuration, at **1430**, if $\alpha=\alpha_{TO}$, the system can close the hydraulic valve **410** to lock the landing gear **305**, **310** at AOA_{TO}.

[0104] At **1430**, the system can determine if the aircraft has lifted off. As discussed above, this can be achieved by measuring the position of, or the load on, the landing gear **305**, **310**. If the landing gear **305**, **310** is fully "stroked out," for example, then the system can determine that the plane has taken off. This can also be determined when the load on the landing gear **305**, **310**, F_{LG}, drops below a predetermined level F_{MIN}—i.e., $F_{LG} \leq F_{MIN}$. This can also be determined by input from an altimeter, GPS, or other flight instrument on the aircraft.

[0105] Regardless of how liftoff is determined, at **1440**, the hydraulic valve **410** is either already open, or the method **1400** can open the hydraulic valve **410** to enable the landing gear **305**, **310** to reposition. In some examples, as discussed above, the weight of the main gear can be used to simply "pull" the fluid back from the nose hydraulic cylinder **320***b* into the main hydraulic cylinder(s) **320***a* to retract the nose gear **310** and extend the main gear **305**. In some examples, the valve can be left open until the landing gear **305**, **310** returns to the ground position, for example, or the AOA position for landing.

[0106] In other examples, the landing gear **305**, **310** can be moved to a "stowed position," where the main gear **305** and nose gear **310** are moved to a position in which the main gear **305** and/or nose gear **310** have a reduced volume over the volume the landing gear **305**, **310** occupies when deployed. In other words, a position that minimizes, or at least reduces, the stowed volume of the landing gear **305**, **310**. In other examples, the stowed position may also enable the main gear **305** or the nose gear **310** to avoid an internal structure, for example. This can be useful, for example, to enable the landing gear **305**, **310** to be stowed in the available space, avoiding bulkheads or other equipment. Thus, the landing gear **305**, **310** may not necessarily be stowed in the minimum space available, for example, due to size and shape requirements.

[0107] At **1445**, the system can determine that the landing gear **305**, **310** is in the correct position, which may be, for example, the landing, stowed, or ground position. If the ground position is desired, then the system can determine that the position of the landing gear **305**, **310**, or P_{LG}, is equal to the ground position, or P_{GROUND}, as discussed above. If the landing gear **305**, **310** (or rather, the hydraulic cylinders **320**) is in the correct position, at **1450**, the system can close the hydraulic valve **410** to lock the gear in place.

[0108] Examples of the present disclosure can also comprise a method **1500** for rotating the aircraft upon landing. At **1505**, the system can determine if the aircraft is at some appropriate speed to extend the landing gear. This may be a speed, V that is lower than the maximum flap extended speed, V_{LE}, for example, but above the reference landing speed, V_{REF}. At **1510**, if the plane is at an appropriate speed, the gear can be extended. At **1515**, as before, the system can determine if the pilot is requesting a positive angle of attack. In some examples, the system can determine if the pilot is applying some positive backward pressure on the stick, or if $F_{STICK} \geq F_{MIN}$.

[0109] At **1520**, if the pilot is pulling back on the stick, the system can activate a pump **435** (e.g., a small turbo-pump) and/or open the hydraulic valve **410**. The pump **435** can be used to overcome any bias in the system for the main gear **305** to droop out when in the air. Thus, the pump **435** can provide a slight rearward pressure to the system to cause the main gear **305** to pivot downward and the nose gear **310** to pivot upward. As mentioned above, the hydraulic valve **410** may be used to lock the position of the landing gear **305**, **310**, but is not required.

[0110] At **1525**, the system can determine if the landing gear **305**, **310** is in the correct position to provide the landing AOA, α_L. As mentioned above, α_L can be the same as, or different than α_{TO}. In some examples, α_L may be inherent in the landing gear **305**, **310**. In other words, when the main gear **305** is fully retracted and the nose gear **310** is fully extended, then the aircraft is at the proper attitude for α_L. In other examples, the system can determine whether the landing gear **305**, **310** is in the correct position based on position sensors, or other means, and either idle the pump **435** or deactivate the pump **435**. At **1530**, the system can optionally close the hydraulic valve **410** to lock the landing gear **305**, **310** in the α_L position.

[0111] At **1535**, the system can determine if the aircraft has touched down. Thus, if the force, F_{LG}, on the landing gear **305**, **310** is greater than some minimum force, F_{MIN}, the system can determine that the aircraft has touched down. In some examples, this can be determined using some direct method, such as measuring the position of, or pressure in, the oleo strut **315** or hydraulic cylinders **320**. In other examples, the system can use input from an altimeter, instrument landing system (ILS), or other means to determine the aircraft is on the ground.

[0112] At **1540**, after determining that the aircraft is on the ground, the system can deactivate or idle the pump **435**. If the hydraulic valve **410** was closed previously, the system can also open the hydraulic valve **410**. In some examples, the weight transfer caused by the aircraft braking upon landing can cause the nose gear **310** to pivot upward and the main gear **305** to pivot downward. In some examples, the aircraft may also have a slight forward weight bias to cause the aircraft to rotate slowly back to the ground position. In some examples, the pump **435** can be reversible (e.g., a small turbo-pump) to pump fluid from the nose gear **310** to the main gear **305**. In some examples, the hydraulic circuit (e.g., the hydraulic pipe **405**) can include an orifice, or other restriction, to control the rate at which the nose gear **310** retracts and the main gear **305** extends.

[0113] At **1545**, the system can determine if the aircraft is in the ground position, P_{GROUND}. As before, this can be done in a variety of ways. In some examples, the aircraft is in P_{GROUND} when the nose gear **310** is fully pivoted upward and the main gear **305** is fully pivoted downward. Thus, a slight weight bias towards the nose gear **310** can cause the aircraft to naturally assume P_{GROUND}. At **1550**, the hydraulic valve **410** can optionally be moved to the closed position to hydraulically lock the aircraft in P_{GROUND}. This can be useful if the aircraft does not naturally maintain P_{GROUND}—e.g., both the nose gear **310** and main gear **305** are in some intermediate position in P_{GROUND}. In some examples, it may simply be desirable to lock the position of the aircraft with the hydraulic valve **410** to prevent pitching during, for example, taxiing, refueling, loading, unloading, and maintenance.

[0114] Referring now to FIG. **16**, examples of the present disclosure can also comprise a method **1600** for using mechanically coupled landing gear for an aircraft. Step **1605** of method **1600** includes disposing at least a nose gear

forward of the center of gravity (CG) of an aircraft by a first distance. This may be implemented in accordance with FIGS. **1-15** above. A first distance may be 5 ft, 10 ft, 1 ft, or the like from the CG. A first distance may be a distance from the CG that is at the nose of the aircraft. Nose gear may be connected to a nose linkage which may be configured to respond to changes in a main gear.

[0115] With continued reference to FIG. **16**, step **1610** of method **1600** includes disposing at least a main gear aft of the center of gravity of the aircraft by a second distance. This may be implemented in accordance with FIGS. **1-15** above. A second distance may be 5 ft, 10 ft, 1 ft, or the like away from the CG. The second distance may be aft of at least a portion of a passenger compartment, as discussed above. The main gear and the nose gear may form a tricycle arrangement. In an embodiment, there may be one nose gear forward of the neutral point and two main gears aft of the neutral point. In another embodiment, there may be two nose gears forward the neutral point and one main gear aft of the neutral point.

[0116] With continued reference to FIG. **16**, step **1615** of method **1600** includes transferring movement between the at least a nose gear and the at least a main gear through a mechanical linkage between a nose linkage and a main linkage. This may be implemented in accordance with FIGS. **1-15** above. The landing gear may be configured to permit an increase in an AOA during take-off, as discussed above. The landing gear may be configured to permit a decrease in AOA during landing, as discussed above. In an embodiment, during takeoff, the nose gear may be expanded and the main gear may be compressed. The nose gear and the main gear may be configured to move in tandem, such as through a longitudinal member. A longitudinal member may be used to connect, directly or indirectly, the main gear to the nose gear. The longitudinal member may be a tension cable that translates forces between the nose gear and the main gear. The nose gear may be connected to a pivot piston. Pivot piston may be any pivot piston as discussed herein.

[0117] As discussed above, it is convenient to locate the main gear **305** behind the rear-spar where there is ample room to store the retracted main gear **305** in the "beaver-tail." To allow the main gear **305** to be tens of feet behind the C_G requires a new feature that works in concert with the nose gear **310**. The location of the main gear **305** would normally prevent rotation because there isn't enough aero-dynamic control moment to lift the plane's weight so far ahead of the main gear **305** axles.

[0118] To solve this, the main gear **305** and nose gear **310** are mounted to hydraulic cylinders **320** of approximately equal diameter for all three landing gears (one nose gear **310** and two main gear **305**). The nose gear **310** and main gear **305** are plumbed together with a smaller hydraulic pipe **405** and share hydraulic fluid. The system can be passive so pumps **435** are not necessary but may nonetheless be used. A hydraulic valve **410**, between the nose gear **310** and main gear **305**, can hydraulically lock the system when desired. Connecting the nose and main gear hydraulically allows the plane to rotate about the C_G with no jacking of the plane's weight. As the plane rotates nose-up, the fluid in the main gear **305** cylinders is forced forward to fill the nose gear **310** cylinder where it supports its share of the plane's weight. The piston areas are sized to achieve the needed proportions between main gear **305** squat, and nose gear **310** stroke-out to pivot about the C_G. These pistons mate to conventional oleo struts **315** with the wheels, tires, and brakes.

[0119] The systems **300**, **400** can function for takeoff rotation and landing de-rotation. During other phases like taxi, takeoff, roll up to V_1, or landing after de-rotation, the plane can be locked in the level, or ground, position. Under braking the systems **300**, **400** can be locked to prevent the braking force from jacking the nose upward. This can be done by closing the hydraulic valve **410** in the hydraulic pipe **405** between the nose gear **310** and main gear **305**. Preventing flow from the nose gear **310** to the main gear **305** hydraulically locks the system. A slight bias in nose gear **310** hydraulic or lever ratio can make the plane very slightly nose-heavy. This can prevent the plane from pitching upward if the hydraulic valve **410** is opened during ground operations.

[0120] As discussed above, the hydraulic valve **410** can be opened whenever the pilot shows intent to change pitch attitude but should not open if the stick is bumped or slightly nudged. Thus, a stick-force dead-band of approximately ±5 lbs. can be used. Since takeoff rotation is a safety critical function, the systems **300**, **400** can be a fail-open system.

[0121] The hydraulic pipe **405** (e.g., piping, a hose, or tubing) from the main gear **305** to the nose gear **310** causes the plane to pivot about the C_G without jacking the C_G vertically. This results in dramatically smaller control moments required to place the plane at lift-off attitude for takeoff. The small moment means a small elevon **110** down-load doesn't oppose the plane's natural coefficient of lift at minimum unstick speed, or C_{LVMU}, capability. This improvement in the down force required at Vim results in approximately 29% better C_{LVMU} at a fixed Ground-Angle-Limit (GAL) which is equivalent to about 25 knots in minimum unstick speed (V_{MU}) benefit.

[0122] In one example, the nose gear **310** can be located about three times as far from the C_G in the forward direction, as the main gear **305** is in the aft direction. In this configuration, all three landing gears bear approximately the same "maximum" vertical and braking loads. The main gear **305** maximum load is the static load, and it is approximately the same as the maximum nose gear **310** load which occurs during braking. This means that all three landing gears can use common parts except for the addition of steering to the nose gear **310**. The 3-to-1 leverage difference means that for every foot the main gear **305** squats at rotation, the nose gear **310** extends 3 times as much. This is exactly what is needed for the plane's virtual pivot point to be near the C_G.

[0123] A normal blended wing aircraft with a braking coefficient of 0.7 on the main-gear causes the nose-gear to bear approximately 23% of the total airplane weight (so-called "weight transfer") versus a typical load of around 3%-5%. Since the nose gear **310** has no brakes, however, the effective airplane braking coefficient is only about 0.55. With the systems **300**, **400** disclosed herein, however, the nose gear **310** is more heavily loaded, so brakes may be added while preserving the needed steering power.

[0124] Weight transfer under braking can now be exploited since the nose gear **310** has brakes. The airplane braking coefficient can now be approximately the same as the individual braking coefficient. That is, the full braking effect is preserved for an approximately 29% improvement in overall braking performance. This also benefits takeoff field length and landing field length. Brakes on the nose gear **310** do not diminish steering relative to a traditional lightly

loaded nose gear **310** because the high nose gear **310** load reduces the steer angle required to generate a side-load on the nose gear **310**. The amount of the friction devoted to steering can be very small, allowing full braking while steering, similar to in a car.

[0125] The systems **300**, **400** add hardware that is absent in traditional landing gear. This can increase weight and cost. Landing gear weight includes wheels, tires, brakes, and struts. The struts generally account for about 35% of the total gear weight. Adding the systems **300**, **400** roughly triples the strut weight component. Therefore we can expect the systems **300**, **400** to increase gear weight by 70%. For most airplanes the total landing gear complement is approximately 4% of gross weight (GW) so the systems **300**, **400** hardware adds approximately 2.8% to the GW.

[0126] The standard wheel wells for a blended wing aircraft, however, are generally within the pressure vessel. Thus, the pressure vessel surface area is increased by the side-walls of the wheel well adding approximately 12% to the wall area. To compensate for the wheel well penetrations, the payload compartment is required to grow another 15%. Thus, the pressure bearing wall area of the pressure vessel increases approximately 30%. The pressure vessel of a typical blended wing aircraft accounts for 9% of the total GW. As a result, the price of the gear penetrations is 2.7% in GW. This almost entirely cancels the cost of the systems **300**, **400**. This also does not take into account the reduced drag of the smaller pressure vessel, which more than offsets the weight of the systems **300**, **400**.

[0127] The Federal Aviation Regulations set forth requirements for determining takeoff and landing field lengths. Landing is relatively straight-forward because there is an air distance between the point at which the plane is 50 ft above-ground-level and the touchdown point. Next there is a distance where the plane is de-rotated, so all 3 landing gears are on the ground. Finally there is a braked deceleration to zero speed. The systems **300**, **400** reduce the braked deceleration portion by approximately 500 ft., equivalent to an approximately 11% reduction in landing field length (LFL).

[0128] System and methods for mechanically rotating an aircraft about its C_G are disclosed. The system can use a variety of actuators to lower the main landing gear and/or raise the nose landing gear to achieve a desired AOA for takeoff, landing, or other flight or ground regimes. The system can use a passive hydraulic system, an active hydraulic system, or electrical or pneumatic actuators, among other things. The system can enable the aircraft to rotate about the C_G, to reduce the aerodynamic control forces required due to weights and balances, landing gear or wing placement, or other factors. The system can be used on blended wing, delta wing, tube and wing, and other aircraft configurations.

[0129] While several possible embodiments are disclosed above, embodiments of the present invention are not so limited. For instance, while several possible configurations of hydraulic cylinders, linear actuators, valves, and motors, other suitable actuators and controls could be selected without departing from the spirit of embodiments of the invention. In addition, the location and configuration used for various features of embodiments of the present disclosure can be varied according to a particular aircraft, airport, or landing gear design that requires a slight variation due to, for example, size or weight constraints, runway length, aircraft type, or other factors. Such changes are intended to be embraced within the scope of the invention.

[0130] The specific configurations, choice of materials, and the size and shape of various elements can be varied according to particular design specifications or constraints requiring a device, system, or method constructed according to the principles of the invention. Such changes are intended to be embraced within the scope of the invention. The presently disclosed embodiments, therefore, are considered in all respects to be illustrative and not restrictive. The scope of the invention is indicated by the appended claims, rather than the foregoing description, and all changes that come within the meaning and range of equivalents thereof are intended to be embraced therein.

What is claimed is:

1. A landing gear for an aircraft comprising:

at least a nose gear disposed longitudinally forward of a center of gravity of an aircraft by a first distance and connected to a nose linkage configured to transfer movement from the at least a nose gear to at least a main gear;

at least a main gear disposed longitudinally aft of the center of gravity of the aircraft by a second distance and connected to a main linkage configured to transform movement from the at least a main gear to the at least a nose gear; and

wherein the at least a nose gear and the at least a main gear are mechanically linked.

2. The landing gear of claim **1**, wherein the landing gear is further configured to permit an increase in an angle of attack of the aircraft during take-off.

3. The landing gear of claim **1**, wherein the landing gear is further configured to permit a decrease in an angle of attack of the aircraft during landing.

4. The landing gear of claim **1**, wherein the at least a main gear is located aft of at least a portion of a passenger compartment.

5. The landing gear of claim **1**, wherein the at least a nose gear is located at the nose of the aircraft.

6. The landing gear of claim **1**, wherein the at least a nose gear is connected to a pivot piston.

7. The landing gear of claim **1**, wherein a longitudinal member mechanically links the nose linkage and the main linkage.

8. The landing gear of claim **7**, wherein the longitudinal member comprises a tension cable.

9. The landing gear of claim **1**, wherein the aircraft comprises a blended wing body (BWB).

10. The landing gear of claim **1**, further configured to form a tricycle arrangement.

11. A method of using a landing gear for an aircraft comprising:

disposing at least a nose gear forward of the center of gravity of an aircraft by a first distance;

disposing at least a main gear aft of the neutral point of the aircraft by a second distance;

transferring movement between the at least a nose gear and the at least a main gear through a mechanical linkage between a nose linkage and a main linkage.

12. The method of claim **11**, wherein the landing gear is further configured to permit an increase in an angle of attack of the aircraft during take-off.

13. The method of claim **11**, wherein the method is further configured to permit a decrease in an angle of attack of the aircraft during landing.

14. The method of claim **11**, wherein the at least a main gear is located aft of at least a portion of a passenger compartment.

15. The method of claim **11**, wherein the at least a nose gear is located at the nose of the aircraft.

16. The method of claim **11**, wherein the at least a nose gear is connected to a pivot piston.

17. The method of claim **11**, wherein a longitudinal member mechanically links the nose linkage and the main linkage.

18. The method of claim **17**, wherein the longitudinal member comprises a tension cable.

19. The method of claim **11**, wherein the aircraft comprises a blended wing body (BWB).

20. The method of claim **11**, further configured to form a tricycle arrangement.

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